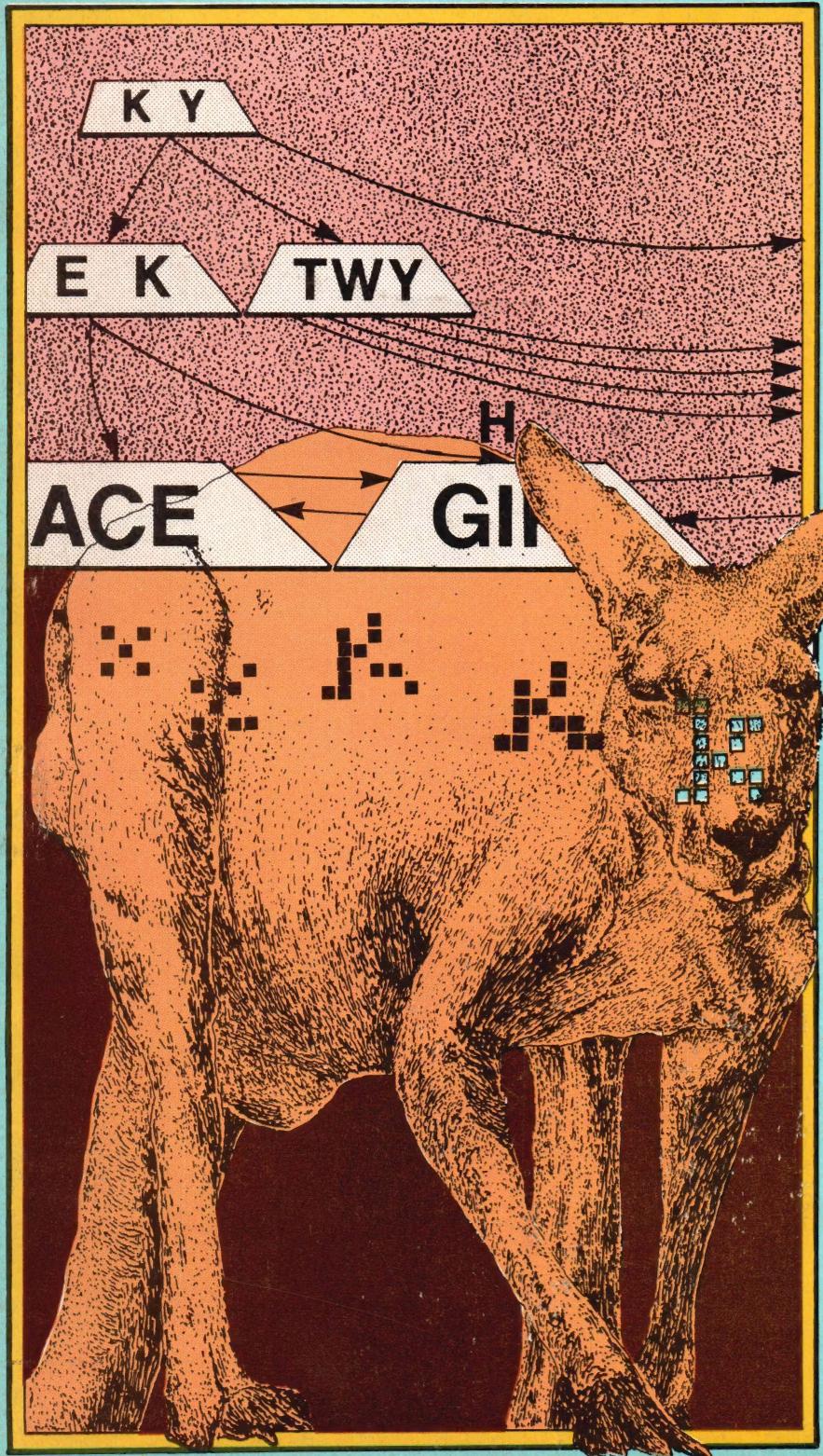


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Dr. Dobb's Journal

For Users of Small Computer Systems

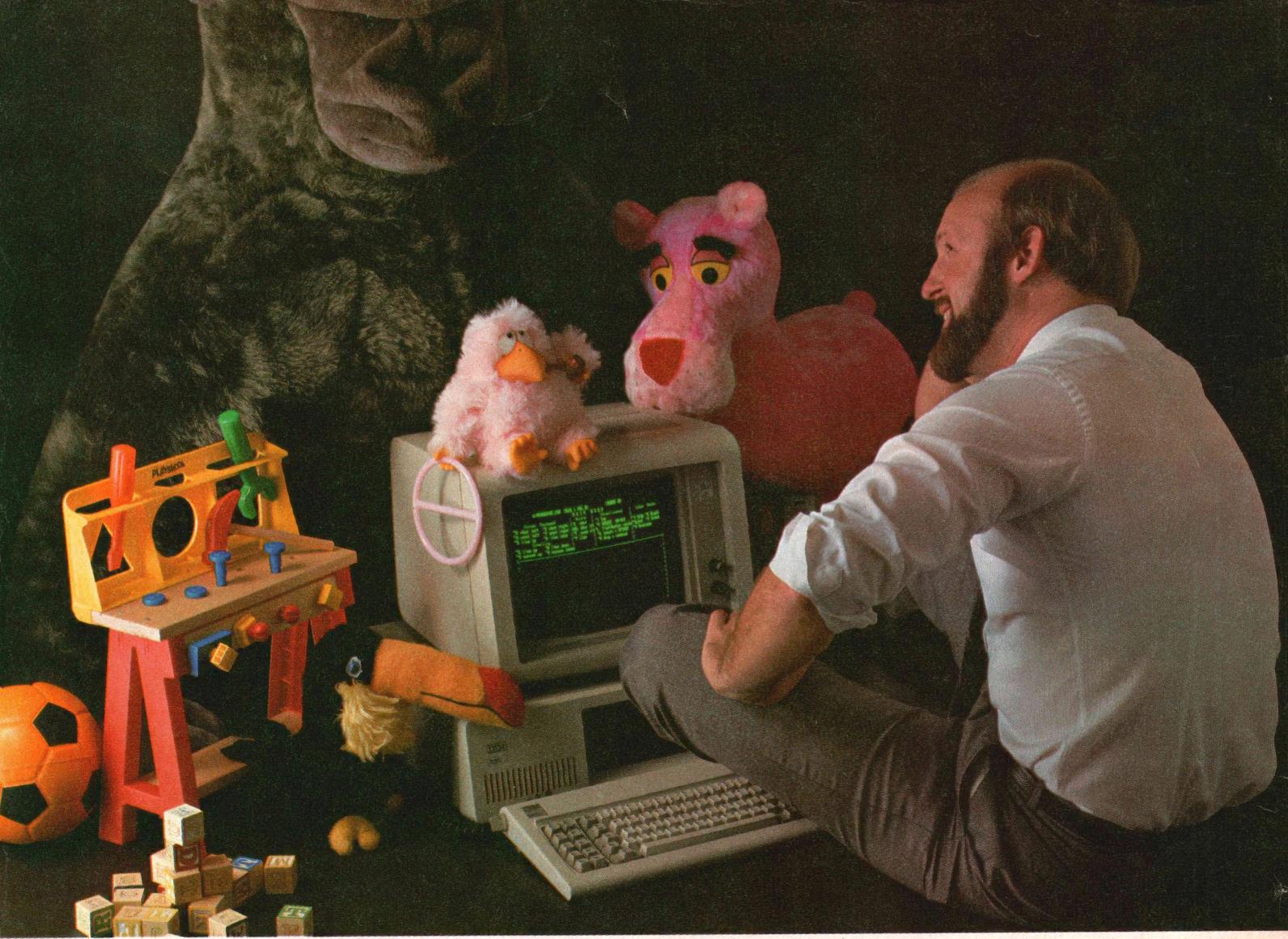


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```
MICRO/SPF PRIMARY OPTION MENU
SELECT OPTION ==> _          USERID - Username
                                TIME - Lasttime
                                TERMINAL - Phaser
                                FF KEYS - 12
0 SPF PARMS - SPECIFY MICRO/SPF PARAMETERS
1 BROWSE - DISPLAY SOURCE DATA
2 EDIT - CREATE OR CHANGE SOURCE DATA
3 UTILITIES - PERFORM MICRO/SPF UTILITY FUNCTIONS
T TUTORIAL - DISPLAY INFORMATION ABOUT MICRO/SPF
X EXIT - TERMINATE THE MICRO/SPF SESSION
PRESS END KEY TO TERMINATE MICRO/SPF
EDIT - ENTRY PNL
ENTER VERIFY PARAMETERS BELOW:
XIN LIBRARY: PROJECT ==> PHASER
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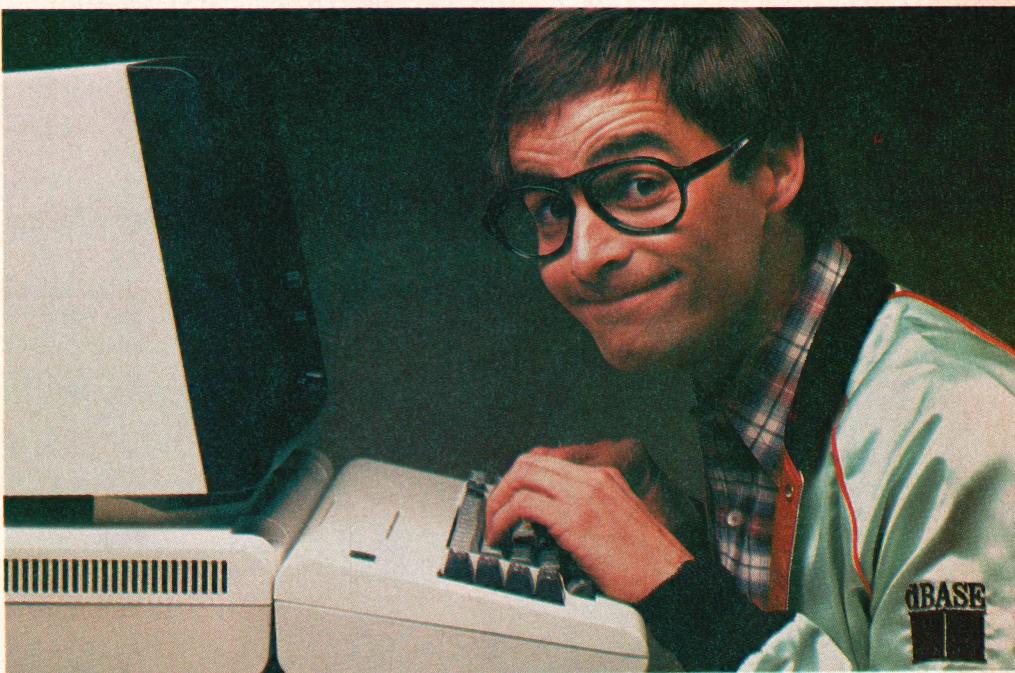
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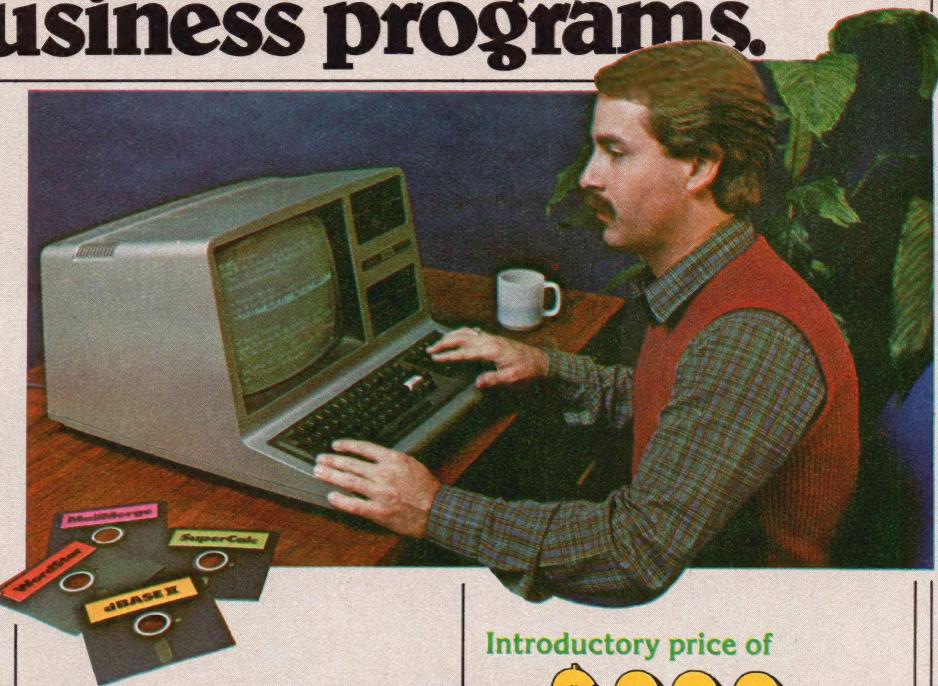
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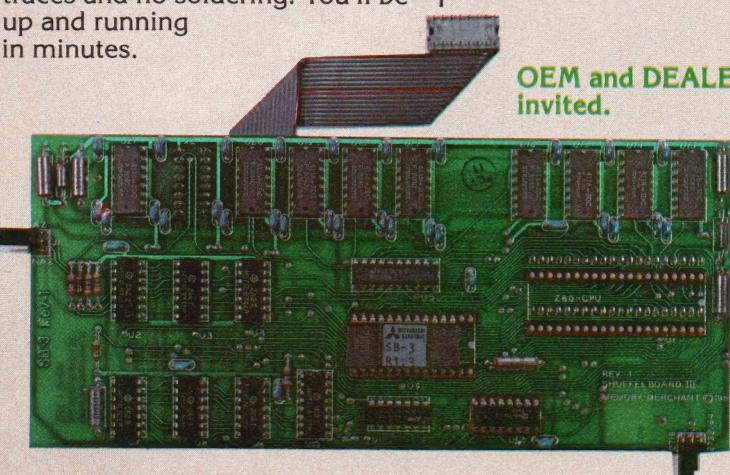
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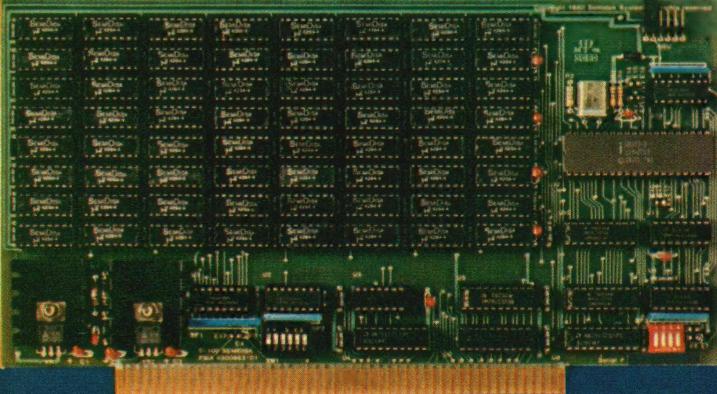
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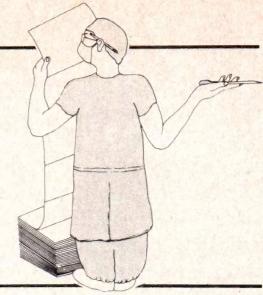
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DR. DOBB'S CLINIC

by D. E. Cortesi, Resident Intern



A Yodel from Yap

John Thayer Jensen, of Yap, TT, writes us as follows. "I have the kiss of death: I bought an IMSAI VDP-80 and that put IMSAI out of business. So the first thing is, if there are any IMSAI VDP-80 owners out there who will write me, I can share a partially commented disassembly of IMDOS's BDOS, similar disassemblies of the DIO and VIO ROMs, and can sometimes answer questions about IMDOS and IMSAI hardware."

"I also bought a now-obsolete multi-tasking operating system called FAMOS from MVT Microcomputing. They never sold any more (as far as I can tell) and while they make a token effort at support, they can't be expected to do much — and the thing doesn't work. If there are any FAMOS users reading this, I have next to nothing to offer, but an infinite number of questions to ask someone!"

"It would be wonderful to hear from some fellow VDP-80 and/or FAMOS users. I can't check into CBBSSs, can't go to meetings, can't phone anyone. We have a U.S. zipcode, proving that we are not at the end of the world (although on a clear day, you can see it from here), and domestic first-class mail will reach us by air."

If you would like to correspond with Jensen in his lonely outpost (Yap is an island in the mid-south Pacific), you can write to him at P.O. Box 358, Yap, TT 96943.

PC Still Backward

In March we expressed our puzzlement at the results of printing an ASCII backspace from BASIC in the IBM PC. The result of

PRINT CHR\$(8)

is precisely nothing, while the result of

PRINT "wotizzit:",CHR\$(8)

is (as we described it) a small reverse-video diamond which we couldn't find in any manual.

Several readers responded. Randolph Fritz of Mahwah, New Jersey and Bob Taylor of Buffalo, New York wrote to point out that the complete character set is shown on pages C-12 and C-13 of the *IBM Technical Reference*, and it includes the one we couldn't find. Robert Pirko of New York added that "The funny character you see is intended to be a reverse-video circle. For the graphics adapter in the 40-character mode, it looks roughly like a circle. In the 80-character mode,

the width is cut in half and the circle does look more like a diamond."

David Kellogg, also of New York, called to say the same, and added that if you print character 226, the *Technical Reference* says you should get a lowercase gamma, but you actually get an upper case gamma.

OK. The whole situation is very confusing, but we think we understand it now. Follow us through this. (1) IBM, for whatever reason, implemented a graphic symbol for every byte value from 001 to 254 inclusive, leaving only 000, 032, and 255 as blank or null displays. The bytes from 032 to 127 have their ASCII symbols; the others produce unique special characters. (2) The PC's ROM implements a simple dumb-terminal function (WRITE-TTY) which takes ASCII bytes and displays them. It implements the control characters as a teletype would, including carriage return (CR), line feed (LF), and backspace (BSP). However, WRITE-TTY does not implement cursor addressing (as any modern terminal should, no matter how dumb).

But (3) the BASIC interpreter needs direct cursor addressing for its screen editing, so it calls upon the more primitive routines in ROM. These routines supply cursor positioning and screen output (SET-CPOS and WRITE-AC-CURRENT). Since they are not trying to emulate a terminal, they treat ASCII control characters as data. A control character like BSP, sent via WRITE-AC-CURRENT, will go into the screen display as a symbol; it will not have its standard ASCII effect.

Then (4) the BASIC interpreter also used the primitive ROM functions to implement the PRINT statement; thus any character written via PRINT will go straight to the screen as a symbol.

Except that (5) the interpreter wants to supply some modicum of standard control characters, so it intercepts BEL (and toots the horn), CR (and returns the cursor), TAB (and tabs by 8), LF (and moves the cursor down), and FF (and clears the screen). In effect, it does the job of WRITE-TTY, but in the interpreter code. It should intercept BSP as well; it apparently does so when the cursor is at the left margin, but not otherwise. So a backspace at the left margin acts like a backspace (doing nothing), but once away from the margin, it gets through and becomes a symbol. This appears to be a bug in BASIC.

Finally (6) the interpreter wants users to be able to move the cursor freely, so not only does it implement the LOCATE verb, it also intercepts the ASCII control characters US, RS, FS, and GS and treats them as commands to move the cursor in the four cardinal directions.

The net: a BASIC programmer has two ways to position the cursor (neither compatible with any other BASIC), but lacks both a standard backspace and the nonstandard symbols of bytes 028-031. Meanwhile, the user of another high-level language can use the backspace (since most of these use WRITE-TTY) but cannot move the cursor. This is how your major corporations do whatcha call your systems analysis and design stuff, see?

SuperKludge

Nick Hammond, now of Torrens, Australia, has sent us a lovely kludge for CP/M 2.2. Here's what he says.

"A couple of months ago, I was asked to modify an 8-inch, single-sided, single-density CP/M system to allow a larger-than-standard directory. It proved to be a fairly simple mod and I thought you might like to share it with your readers.

"A standard 8-inch, single-density CP/M diskette has a file directory that will hold 64 entries. Since each 16K extent of a file requires one entry, this may amount to less than 64 actual files. Given the maximum data storage of 240K odd, this is a reasonable number, but occasions will arise when we need more. The example that prompted this note was a need to fit a dBase II application with a large number of command files onto one disk, leaving the second free for data.

"Fortunately, CP/M 2.2 is both flexible and well thought-out, and expanding the directory can be done relatively simply. Two things must be done: generation of a diskette which will look okay to both the standard and modified systems, and insertion of a two-byte patch to modify the BIOS for the new directory size.

"The standard directory on a single-density 8-inch disk occupies the first two 1K blocks after the system tracks. The modified directory will occupy the first four, and we therefore need to reserve the third and fourth blocks. If this is not done, the directory could be overwritten when used with an unmodified BIOS, and would then appear full of garbage when used with a modified one.

"We can reserve the extra directory blocks by making the first file written to disk a dummy, full of E5 bytes. To the standard system, this will appear as a normal file; to the modified system, the E5 pattern will look like two blocks of empty directory space. To ensure that the dummy file occupies the third and fourth blocks, it must be written under a standard system and it must be the first file on the diskette. If your SYSGEN procedure copies hidden files to the new disk, the dummy file must be written before you SYSGEN the disk. The following DDT session illustrates the procedure.

```
A > ddt
DDT VERS 2.2
-f100,900,e5      fill 2K with E5h
-g0                exit DDT
A > save 8 b:empty  save dummy file
A > stat b:empty $sys and hide it
```

"CP/M gets its information on directory size from the Disk Parameter Block (DPB), a data area contained in the BIOS. To enlarge the directory it is necessary to alter two bytes in the DPB. The first is DRM, a count one less than the number of directory entries. The second is ALLOC0, a bit-map of the disk blocks reserved for the directory.

"The DDT session that follows shows how to find the DPB and how to make a

small command file, KLUDGE.COM, to alter it. The DPB that this procedure locates is the one for the default drive. In most systems there is only one DPB for each disk format and the modification will affect all drives. If it doesn't on yours, just repeat the exercise with a different drive logged in.

```
A > ddt
DDT VERS 2.2
-a100              assemble a program
0100 mvi c,1f      to locate the DPB
0102 call 5
0105 rst 7
0106 .
-g100              execute it
*0105

-x                  HL has the address
C0Z1M0E110 A=14 B= ... H=FE14 ...
-hfe14 e           calculate its size
FE22 FE06
-dfe14 fe22        dump it to make sure
FE14 1A 00 03 07 00 F2 00 3F 00 C0 ...
FE20 00 02 00 ...

-a100              assemble a program
0100 mvi a,7f      to patch the DPB
0102 sta fe1b      ... change DRM to 127
0105 mvi a,f0      ... reserve 4 blocks
0107 sta fe1d      ... in ALLOC0
010A ret
```

010B .

-g0

A > save 1 b:kludge.com

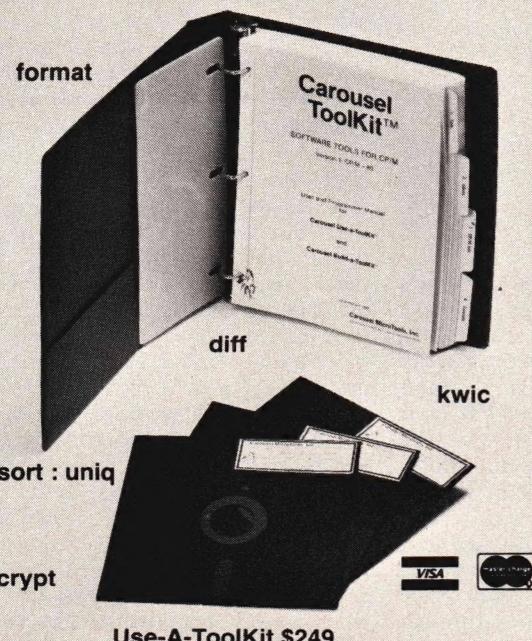
"After running KLUDGE, the directory will have space for 128 entries, and should stay that way until the next cold boot, which overwrites the BIOS. Some manufacturers such as Osborne have chosen, for reasons best known to themselves, to rewrite the BIOS at warm boot also, contrary to CP/M specifications. On these systems, KLUDGE will have to be run after each boot." [A BIOS that supports multiple formats may rebuild the DPB when a disk is selected after a warm start - DEC.]

A Stack of Boots

Aubrey Hutchison has checked in with a warning for users of the California Computer Systems BIOS supplied with the 2422 disk controller board. "After running for 18 months," he writes, "I found a problem that was bothering me from time to time. At times when using PIP, the machine would appear to hang up; at other times it would seem to PIP forever; but most of the time PIP worked as expected."

"The problem turned out to be related to the CCS boot code and boot ROM. The stack pointer is set by the ROM to be

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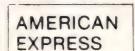
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the top of RAM — 56Kb in my case, since at boot time the top 8Kb of RAM is banked out. When the ROM enters the cold-boot routine loaded from disk, it leaves the stack in the same place. The cold-boot routine doesn't change it. The CCS BIOS did not set the stack pointer either [*it sets it on a warm boot but not a cold one — DEC*] so until the CP/M CCP took over, the stack was not set at some other location. Since the BIOS used the stack for one or two (maybe three) levels, the stack was having a good time playing around in the BDOS. The damage must have been small since I used it in this condition for 18 months.

"My method of correcting the problem was to fix the location of the stack at the entry to the cold-boot routine. I found space to insert

```
1xi h,0100h
sphl
```

at the start of the cold-boot code without changing the original code. The same thing could be done in the BIOS [*at label BOOT*]."

What do you suppose the BDOS has in its highest two or three words that overwriting them would cause trouble, but only rarely?

The Intern's 2.2 BIOS

In the last couple of columns we talked about the fancy BIOS we built for a CP/M 2.2 system with banked storage. We have CP/M 3 running now, and in building its BIOS we had to pretty much rip up the new 2.2 BIOS and lay it down again. It seems a shame to let such a pretty thing die so soon, but we really have no more use for it. And who else would, unless they had exactly our hardware configuration? Or unless they had a masochistic desire to read approximately 95 pages of heavily commented Z80 assembly code....

If you have such a masochistic desire, you can have a copy of our 2.2 BIOS for your bedside reading. Send your own 8-inch, single-density diskette and a sturdy self-addressed, postage-paid diskette mailer, and we'll duplicate the source files onto it. Address the package to "The Intern's 2.2 BIOS" c/o PCC, P.O. Box E, Menlo Park, CA 94025. Note that you should not expect to actually *use* this code. If you have any idea for doing so, be aware that it needs RMAC and LINK; it comes with minimal documentation; and it carries *absolutely no warranty or support of any kind*.

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CP/M Plus — Sector Buffering

The CP/M 3 (or CP/M Plus) BDOS buffers disk sectors in storage in an attempt to speed up processing. The attempt may be successful in some cases (we haven't tried any direct-access I/O yet), but the BDOS uses its sector buffers in a way that is far from optimal for sequential I/O. This is demonstrated by some experiments we made recently.

A CP/M 3 BIOS for a banked system supplies the address of two words in storage in the Disk Parameter Header that it returns from a SELDSK call. These are the anchors of two chains of Buffer Control Blocks (BCBs). Each BCB describes a buffer that the BDOS may use to save a disk sector (a physical sector, not a 128-byte logical sector). There are separate chains for directory and data sectors. According to the *CP/M 3 System Guide*, page 8, "In a banked environment, CP/M 3 maintains a cache of deblocking buffers and directory records using a Least Recently Used (LRU) buffering scheme." And on page 46, "In general, you can enhance the performance of CP/M 3 by allocating more BCBs."

Always anxious to improve performance, we gave CP/M 3 a grand total of 71 sector buffers, each one a kilobyte, spread over our four-bank system. Seventy-one kilobytes of data space (plus another 8K of directory buffers) is not exactly a SemiDisk, but it's a lot more buffers than

(Continued on page 89)

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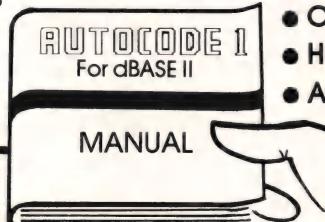
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Fast Divisibility Algorithms

It is well known that the lowest digit of an integer, if not 1, 3, 7, or 9, suffices to establish divisibility by 2, 5, or 10. Algorithms for divisibility by other small integers (such as 3, 7, 9, or 11) are not common knowledge. They require information from *all* the digits of the number, and are too complex to be part of elementary arithmetic but too trivial for the mathematical elite. Even the "obviously divisible" integers contain useful information in the next-to-last digit. E.g., numbers ending in 5 are divisible by 25 if the preceding digit is 2 or 7, while numbers ending in 0 are divisible by 25 if the preceding digit is 0 or 5. Numbers ending in 2 or 6 are divisible by 4 if the preceding digit is odd — if it is even, the number has only a single factor of 2; the opposite is true of numbers ending in 0, 4, or 8.

The algorithm for divisibility by 3 or 9 is relatively simple. It requires information from *all* the digits, but is independent of the *order* of the digits. It calculates the "reduced digit-sum" by adding all the digits; whenever this becomes 10 or more, 1 is added to the low digit and the high digit is discarded so that the sum is always a number from 1 to 9. If the final reduced sum is 9, the number is divisible by 9. If it is 3 or 6, the number has a single factor of 3. E.g., the number 123456789 has a reduced sum of 9 and so is divisible by 9. This is true of all the possible permutations of these digits, and also true for 12345678 and all its permutations. However, 1234567 has a reduced sum of 1 and so cannot be divided by 3, nor can any of its permutations. The presence of zeroes within the numerical sequence does not affect the truth of the algorithm; e.g., 45, 405, 4005 all are multiples of 9, and so of 45.

The algorithm for divisibility by 11 is somewhat more complex, since it depends on the *order* of the digits (only a fraction of the possible permutations being multiples of 11). It requires the calculation of *two* digit-sums. The "high" sum is that of the first, third, fifth, etc. digits; the "low" sum is that of the second, fourth, sixth, etc. digits. Within each of these sets, however, the order of the digits does not affect the truth of the algorithm since this requires only that the *difference* between

the two sums be a multiple of 11, or 0. The difference will always be 0 if each sum is reduced by 11, though it is simpler to reduce only the difference, in one step, if it is not 0. An example is the number 12435687 with both high and low digit-sums equal to 18, and so divisible by 11. If one adds the two sums, the value 36 reduces to 9, so the number is divisible by 99. Which set is "high" does not matter; e.g., 21346578 is also divisible by 99, and of course also by 2. Though more complex, this algorithm can test divisibility by 3, 9, or 11 in one operation. For gigantic numbers, the digit-sums can be reduced by 99 since this is a multiple of both 9 and 11 — if a sum reaches 100 it reduces to 1, etc.

These algorithms are valid for number bases other than decimal, although this alters the factoring integers. In octal, successive multiples of the highest digit (7) are 16, 25, 34, 43, etc., so that numbers of any size will yield a total reduced sum of 7, while successive multiples of its base (8) + 1 (= 9) are 11, 22, 33, etc. In hexadecimal (base 16), the total reduced sum of numbers factorable by its highest digit (F, = 15 decimal) must always be F (e.g., 1E, 2D, 3C, etc.), while the "elevenish" series (11, 22, 33, etc.) has all multiples of decimal 17.

As in the decimal "base minus 1" algorithm, in which reduction by 9 reveals multiples-of-3 when the reduced sum is 3 or 6, so in hexadecimal does a reduced sum of 3, 6, 9, or 12 reveal divisibility by 3 (but not 5), while a reduced sum of 5 or A (decimal 10) reveals divisibility by 5 (but not 3). Only in decimal do multiples of 5 always have 0 or 5 as the lowest digit. The general rule (at least for bases that are even numbers) is that numbers divisible by the digit that is half the base always end in 0 or that digit.

Divisibility by 7 can now be seen to require a general "base minus 3" algorithm, that in octal would recognize divisibility by 5 and in hexadecimal divisibility by 13. I have only studied the algorithm for decimal notation. It is even more complex than divisibility by 11, requiring not only calculation of a similar high and low pair of digit-sums, but positional "weighting" of each digit. The *order* of the digits in each set is significant. Relatively few permutations within each set retain divisibility by 7, since only digits with the same weighting factor can be interchanged. Weighting involves multiplication by 1 (i.e., no change) for the

first, fourth, seventh, etc. digit (reading the number from left to right), multiplication by 2 for the second, fifth, eighth, etc. digit, and multiplication by 4 for the third, sixth, ninth, etc. digit. However, digits can be reduced by 7, to a pseudo-heptal notation; i.e., 7 becomes 0, 8 becomes 1, and 9 becomes 2. Also, the product of a digit by its weighting factor can be reduced by 7; e.g., if the digit is 6 and its factor is 4, the product (24 = 3 · 7 + 3) can be replaced by 3. Since such repetitive calculation would slow the algorithm down, the operation of replacing each digit by its weighted and reduced digit can be done by the following look-up table:

Decimal Digit to be "Replaced"

Order	1	2	3	4	5	6	7	8	9
1	1	2	3	4	5	6	0	1	2
2	2	4	6	1	3	5	0	2	4
3	4	1	5	2	6	3	0	4	1

For example, the algorithm alters the number 421589637 to 444521660, which has 16 for both its high and low digit-sums. The original number is therefore divisible by 7 since this requires that the difference be either 0 (as in this case) or also a multiple of 7. Since this number also happens to be divisible by 9, it is divisible by 63. Another example is 10101, which alters to 10402 with a high digit-sum of 7 and a low of 0, revealing divisibility by 7 and (since the total unaltered digit-sum is 3) by 21.

All these divisibility algorithms involve no actual division. They only determine whether division by the small prime being tested is possible, and can do this relatively quickly even for gigantic numbers by reducing them to much smaller numbers that retain the same divisibility. A high proportion (56.6%) of very large random numbers ending in 1, 3, 7, or 9 will be divisible by 3, 7, or 11 and so can be proved to be non-prime. Algorithms for divisibility by higher small primes (13, 17, 19, etc.) could surely be devised, but would "sieve out" ever-decreasing fractions of non-primes at an ever-increasing cost in complexity. However, one never knows when exotic algorithms may prove useful, if only as clues to far more powerful ones.

One human-interest element is that I did a casual search for these algorithms in various math books, in the certainty that

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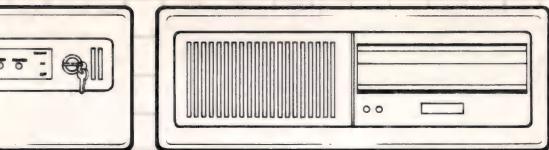
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they were known, but failed to find them. Rediscovering the 3-6-9 and the 11 algorithms – by simple inspection of the digit sequence of small multiples – was child's play. Subsequently I found these algorithms on pages 25-27 of the *VNR Concise Encyclopedia of Mathematics*, recently published (or reprinted) by Van Nostrand Reinhold. This is the work of East German mathematicians and presents a few uses in detection of errors in complex calculations. It omits the divisibility-by-7 algorithm, though I'm certain this was also discovered (probably more than once) long ago. I found it less obvious than the simpler algorithms. Its computational drudgery would, in the pre-computer era, have discouraged its use. Even the extension to other number bases has probably been done before, though like other things the elite see as trivial, it has been forgotten! The VNR Encyclopedia reference pointed out something I had ignored, that what I've called the "reduced sum" is not useless even when non-divisibility is found, since it is then the remainder that would be obtained if the division were actually done. Perhaps the divisibility-by-3 algorithm could be used to test random-number generators, since 1/3 of a fairly large sample of large numbers ought to be divisible by 3, 1/3 should have a remainder of 1, and 1/3 a remainder of 2.

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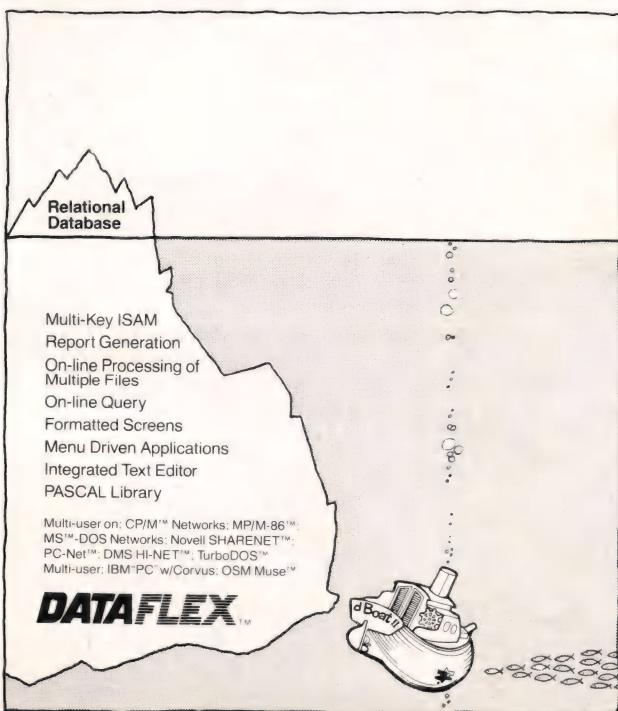
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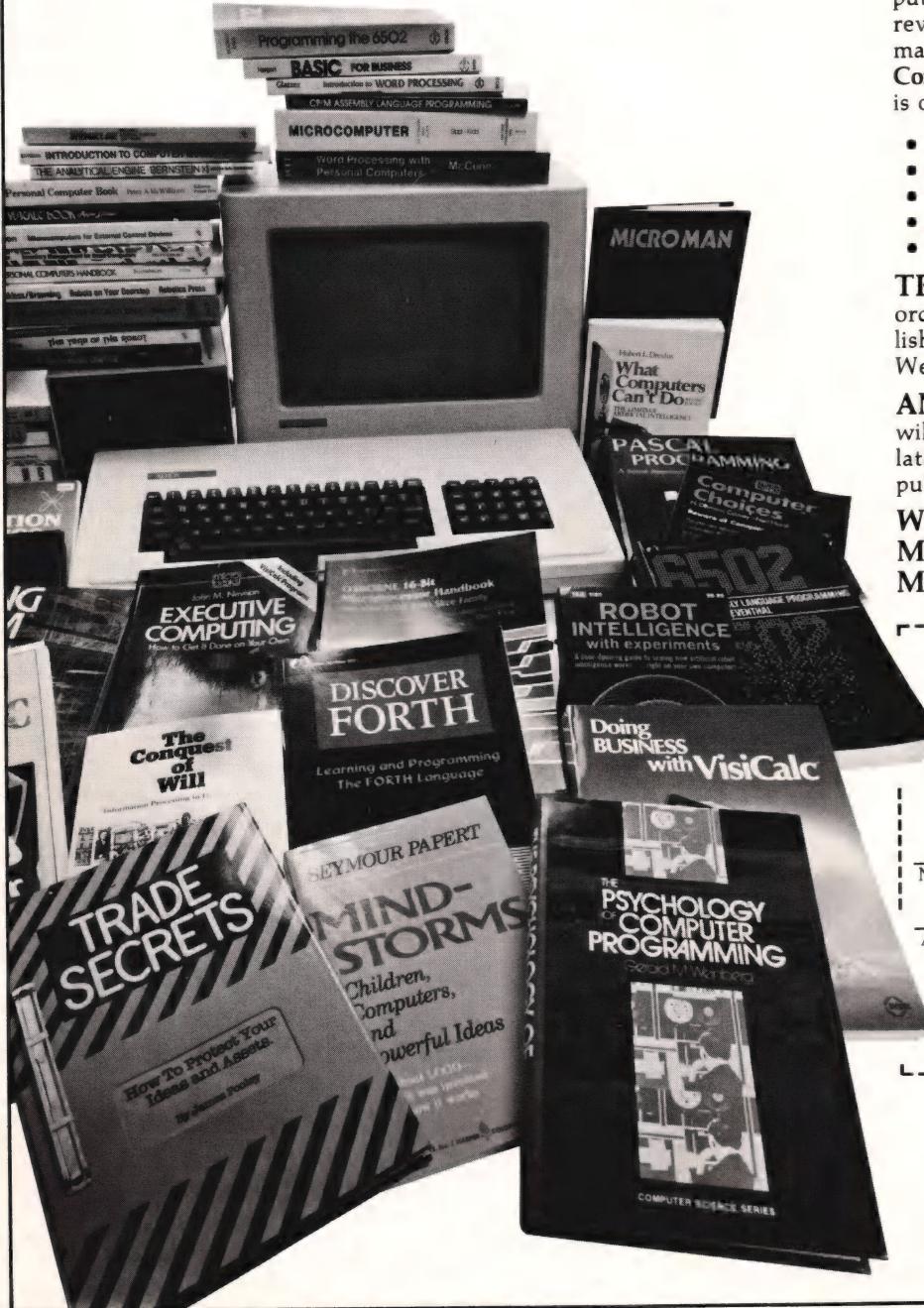
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B-Tree ISAM Concepts

How do you retrieve random information quickly from a large disk file? Every programmer who has written software for business has had to deal with this problem. Fortunately, computer scientists have refined an elegant and simple method for retrieving information called a B-Tree. The objective of this article is to explain the principles and techniques involved in a B-Tree.

Why ISAM?

With current hardware technology, about the only way to quickly retrieve information out of a disk file is using an indexing method. There are many methods of indexing data. ISAM, Indexed Sequential Access Method, has become very popular for use in many business systems. It allows the information to be retrieved randomly by data value (indexed) and in sorted order (sequential) using just one index file. This dual ability is what distinguishes ISAM from other methods, such as Hashing. While there are many ways to implement an ISAM index, the B-Tree is generally accepted as being the current "state of the art."

General ISAM Principles

An ISAM file is a file composed of individual pieces of information called "keys." A key is an ASCII string representing some value in a data record. The index is arranged in such a way that keys can be retrieved randomly and sequentially, along with their associated data record numbers. There are a number of different schemes designed to serve this purpose, a B-Tree being only one. To better appreciate the B-Tree, we will look at an older method, called the binary tree.

A tree structure is called such because if all the search paths are drawn out, they resemble an inverted tree as shown in Figure 1 (at right). The search starts at

the root and progresses down the tree until it possibly reaches the bottom (called leaves, or leaf level). Note also in Figure 1 that from any point in the tree, there are two paths to the next lower level, hence the term "binary tree." In a simple binary tree, each key is stored in an individual record, or node. Each node also has two pointers to other nodes. These pointers are what make up the search paths through a tree.

A search through a binary tree is, on a basic level, a simple procedure. To find the key "G," it is first compared to the key in the root node. If "G" matches, then the search is successful. Otherwise, a decision must be made, that is, where to go next. If "G" is smaller than the root node, then the path to the left is taken. If "G" is larger than the root, then the path to the right is taken. The path is followed and the new node is read. "G" is then compared to the key in this node as before, and the appropriate action is taken. The search continues until either "G" is found, or a leaf node is unsuccessfully evaluated.

As long as the nodes are kept in memory, the binary search is an efficient method. Once the nodes are stored on the disk, however, the performance quickly degrades because of the large number of disk accesses required.

Other problems can also arise when keys are inserted. This can have the effect of making the tree unbalanced — that is, some search paths being longer than others. This requires that the search and

insertion algorithms be aware of this possibility, and subsequently these procedures become much more complicated.

The Basic B-Tree

The problems with the binary tree in large disk-based filing systems gave an incentive for researchers to look for something better. In the late 1960s a number of people independently designed such a method called a B-Tree. Apparently the reason for the name, B-Tree, seems to be the fact that R. Bayer, then at Boeing Scientific Research Labs, was one of the pioneers of the method ("Bayer-Tree").¹

Figure 2 (page 19) shows an example of the B-Tree format. The most obvious difference between a binary tree and a B-Tree is that from any one node there can be more than two paths to the next node. This has the effect of allowing many more keys in each node of a B-Tree than with a binary tree. For instance, a binary tree with ten-byte keys, holding one million keys, could take as many as twenty node searches to find any one key. A B-Tree with the same conditions (assuming ten keys per node) would at the most take five node searches. In the case where node searches correspond to disk accesses, the search time difference is obviously dramatic.

Searching a B-Tree

To find a key in a B-Tree, the first step is to look at the root node. In the

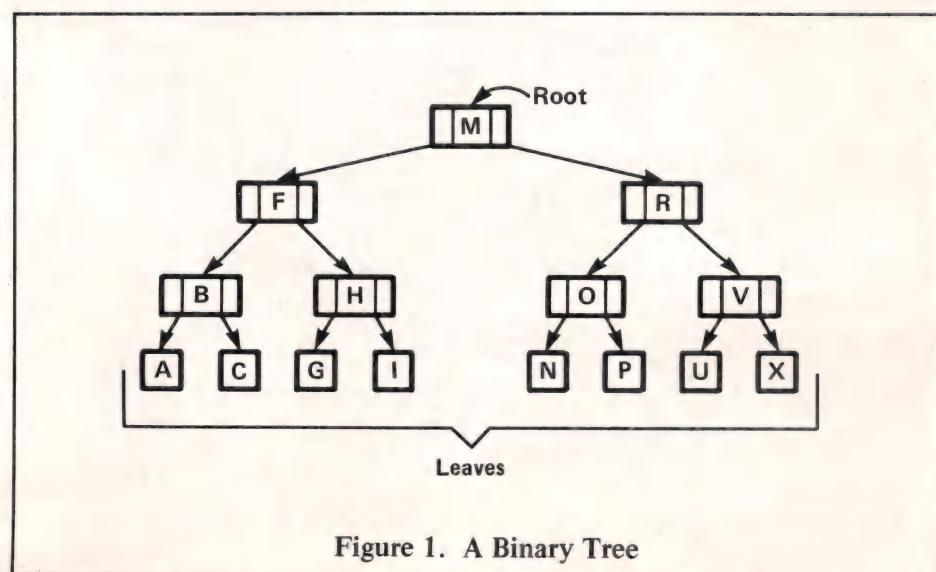


Figure 1. A Binary Tree

by Chris Deppe and Alan Bartholomew

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Alan Bartholomew, Business Computing, 2210 Wilshire Blvd., Suite 289, Santa Monica, California 90403.

Chris Deppe, 6333 Canoga Avenue #191, Woodland Hills, California 91367.

example shown by Figure 2, there are a maximum of three keys in each node. To decide what to do, a process called scanning is used. This involves sequentially looking at each key in the node (note they are stored in ASCII sequence) and stopping when either a matching key is found (in this case, the search is successful, and it ends) or a higher key is found. If no match is found, then a decision must be made.

Take, for example, a search for the key "L." By scanning the root node in Figure 2, we find that there is no matching key. We therefore must follow a pointer to the next lower level. The pointer to follow is the one which sits where the key "L" would be if it existed in the node. In this case we would follow the middle pointer to the next lower node. This node is then read and the same procedure is followed. This continues until either the key is found, or a leaf node is unsuccessfully scanned.

Inserting into a B-Tree

Note that since we must determine where the key would sit if it existed in the node, we now have the needed information to insert the key. Insertion into a B-Tree uses the search already described. Then the key is simply inserted into the node where it should be. Note that keys are always inserted into leaf nodes (an insertion depends not on finding the key, but on finding a place for it). Since an unsuccessful search always ends at the leaf level, then all keys will be inserted there.

If the node into which the key is to be inserted is full, then a split occurs. The original node and the new key are divided up into two new nodes. Since there is now a new node, a pointer to the new node must be inserted into the level above. Usually the middle key of the two

new nodes is brought up to the next level to be used as a separator. If the node above is also full, then it too might be split. This can continue up to the root. If a split of the root node occurs, a new root node is created so that the tree becomes one level higher.

A B-Tree by nature is always a balanced tree. Since all node expansions are done on the same level, the tree never gets unbalanced. An insertion will never increase the search path to one leaf node and not the others.

Deletion of a key is simply finding the key and taking it out of the node. If a key doesn't reside in a leaf, then a new key must take its place to provide the same paths as the deleted key. This new key is found by getting the next key in sequence from the deleted key.

As stated before, the search time in a B-Tree is much more efficient than in a similar binary tree when stored on disk. Sequential processing in a B-Tree is not so easy, however. Because the keys are distributed between all levels of the tree, keys must be retrieved by following the links up as well as down the tree, working from the left to right. This becomes awkward and slow. Try it by hand using Figure 2 and you will quickly see why.

If the sequential processing of a B-Tree could be improved while retaining the random search efficiency and balanced nature, we would have a much better method.

The B+Tree

This brings us to one of the most important variants of the B-Tree called the B+Tree. Figure 3 (page 21) shows an example of the B+Tree format. In a B+Tree, all the keys are stored in leaf nodes. The upper levels simply provide pointers to the next lower level, and so

on until the leaf level is reached. In addition, all the leaves are linked together. What we have, in effect, is a tree which provides a B-Tree type of path to the proper position in a sequential list of the keys.

Since all the keys reside on the leaf level, sequential processing is now very easy as each key is linked together sequentially in the leaf nodes. This gives the B+Tree the desired additional characteristics of an ISAM while retaining the simplicity of a normal B-Tree.

The B+Tree search uses the upper levels as a roadmap to the next level, and it is only until a leaf is reached that the key is actually looked for. Therefore, all searches use the same number of node reads. Although this guarantees that every search will be a "worst case" of a normal B-Tree, we have seen that this worst case is very good under most circumstances. In addition, since all searches take approximately the same amount of time, a high degree of consistency is achieved, which can have its benefits in a real-world situation.

One nice benefit of the B+Tree structure is that since the upper levels are just pointers, a delete doesn't have to worry about revising pointers (deletes only operate on leaves which have no pointers).

Key searching and insertion methods are basically the same as in a normal B-Tree. The specific B+Tree we implemented uses a scheme which uses the high key from the left node to provide a separator (located in the index node above) between the left node and the right node. For example, in Figure 3, a search for the key "H" would produce the following. First, "H" is compared to the first key in the root node. Since "H" is less than "I" the search proceeds by reading the next

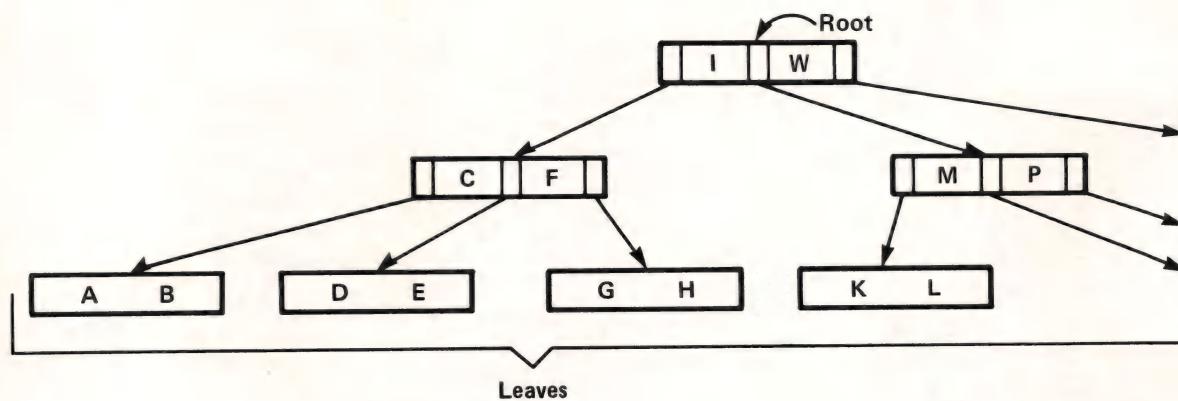


Figure 2. A B-Tree

lower node using the left-most pointer. Then "H" is compared with the first key in the lower node. Since "H" is not smaller than or equal to "C," we must look at the next key. Again, since "H" is not smaller than or equal to "F," we move on to the next key. The next key is "I." "H" is smaller than "I." Since "I" represents the largest value stored in the node its left pointer points to, we follow that pointer.

Splits also use this same high-key logic. At split time, the high key is taken from the left node and it is then inserted (with a pointer to the right node of the split) in the index node above (see Figures 4a and 4b on page 21).

One thing should be mentioned about the B+Tree. Since all the keys are in leaves, the nodes above represent an additional overhead not found in the basic B-Tree, which uses only key values in its tree. With the advent of inexpensive mass storage, though, a slight bit more storage space taken up is well worth the many benefits a B+Tree has to offer.

B-Trees on Micros

Many implementations of the B-Tree ISAM have been created. For example,

IBM uses a variant of the B-Tree for their mainframe computers called "VSAM." More recently, the B-Tree ISAM techniques have been applied to microcomputer applications. For example, dBase II uses a B-Tree method for indexing. Also, a number of companies have developed B-Tree subroutine products for microcomputers. These subroutines can be added to an application being developed. The application programmer uses call statements to the indexing functions built into the B-Tree subroutine without having to be concerned with all the details of how it works.

B-Tree implementations have been produced to support a wide variety of languages. The authors have developed a version written in Forth. Other languages supported by various B-Tree packages include BASIC, Pascal, C, COBOL, Fortran, and others.

For the programmer interested in creating a B-Tree "from scratch," the references for this article will be helpful. These references provide more details about B-Tree techniques and the many subtle variations possible in designing a B-Tree ISAM.

The authors have implemented B-Tree ISAM technology in a Forth utility called INDEX+. Written for Laboratory Microsystems Forth, the package includes fully documented source code and a manual which includes tutorials on B+Tree technology and use of the utility. For more information, contact Laboratory Microsystems.

References

¹ Knuth, Donald E. *The Art of Computer Programming, Volume 3, Sorting and Searching*, Addison-Wesley Publishing Company, 1973.

² Comer, Douglas, "The Ubiquitous B-Tree," *Computing Surveys*, Volume 1, No. 2, June 1979.

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(Figures 3 and 4 at right)

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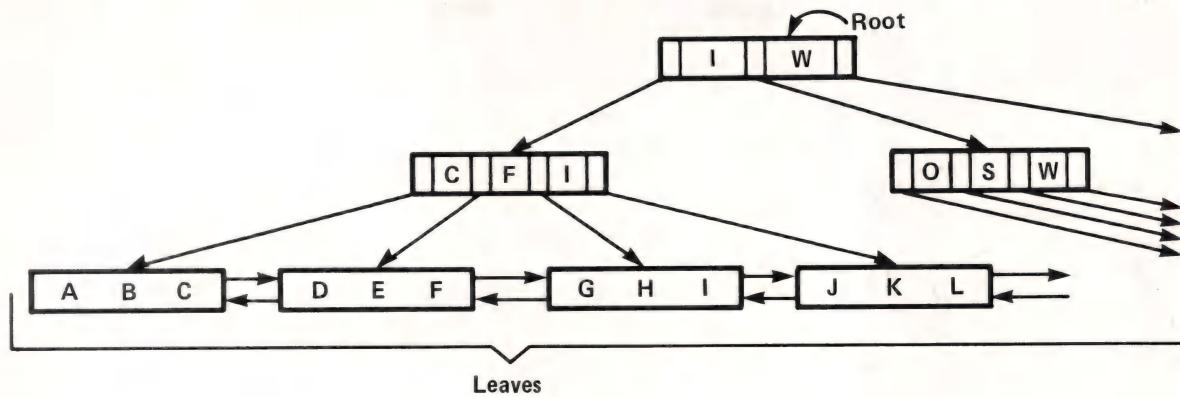


Figure 3. A B+Tree

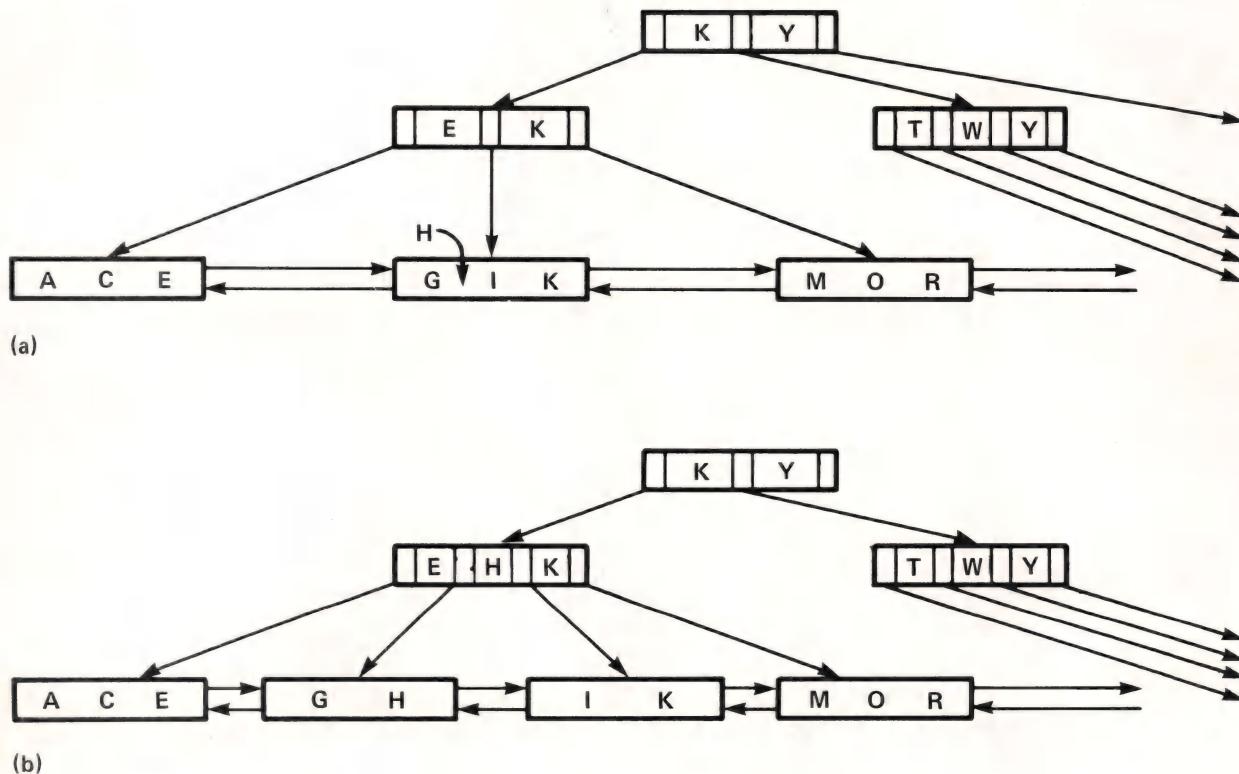


Figure 4.

Figure 4(a): In order to insert the key "H," the mode to receive it must be split. Figure 4(b): The tree after the split. Note that the new pointer in the upper node is the high key from the left node of the two new nodes.

CP/M BDOS and BIOS Calls for C

If you should want to write CP/M utilities in C, you will probably need facilities to access the BDOS (Basic Disk Operating System) and/or the BIOS (Basic Input/Output System). Many C compilers for CP/M do not include such functions, and several of those which exist have severe limitations, in that they may not return proper values in all cases.

The two functions bdos() and bios() described here will enable you to incorporate direct BDOS and/or BIOS calls in programs written in C. Please note that programs that call bdos() or bios() will not be portable beyond CP/M and the 8080 and Z80 series CPUs.

by Terje Bolstad

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bdos() and bios() were originally written for the C/80 compiler from The Software Toolworks, but they will also compile/assemble/work with other compilers which push arguments on the stack in a non-reversed order before calling a function. Such C compilers include Small-C and most of its derivatives. bdos() and bios() have been tested to work properly with both The Software Toolworks C/80 and The Code Works CW/C compiler.

bdos()

The bdos() function sets machine register C to the function number specified in funct, and the register pair DE to the value given in arg, and initiates a call to BDOS. The function number may be specified numerically or symbolically. No checking of the arguments is done.

If funct is either RETVN (12), RETLV (24), GETAA (27), GETROV (29) or GETDPA (31), bdos() returns the value remaining in register pair HL on return from BDOS. For all other BDOS functions, bdos() returns the value in A, with sign extension. In this way, BDOS error (255 or FF(hex)) is returned as -1.

bios()

The bios() function sets machine register pair BC to the value given in arg1, and the register pair DE to the value given in arg2, and initiates the appropriate BIOS call by transferring control to the BIOS jump vector entry point specified in funct. This entry point may be specified numerically or symbolically. No checking of the arguments is done.

If funct is either SELDSK (9) or SECTRAN (16), bios() returns the value remaining in the HL register after execution of the BIOS call; otherwise it returns the value remaining in register A on return from BIOS, with sign extension.

Note that you must specify all three arguments in the bios() function. If you do not need the last one, you must set it to 0 or any other value.

Installation

You may type the source code in Listing 1 (page 24) into a file called CPMCALL.C. To use bdos() or bios() in a C source file, you must #include "CPMCALL.C" in that file.

A simple example on how to use bdos() and bios() is shown in Listing 2 (page 27). In this example, bdos() is used to get the current disk and bios() is used to print it on the console. You may use

this example to test that you have installed bdos() and bios() correctly on your system. When run, the program should write the uppercase character corresponding to the current (logged) disk drive on the console. Log onto different drives and check that the program writes out the correct letter.

Normally it is not advisable to do input/output via bios() or bdos() (as done with bios() in the example), if this can be done via other conventional C functions, such as putchar().

In order to be compatible with code for other compilers which do offer the same functions (e.g., SuperSoft's C compiler), you should refer symbolically to the bdos() and bios() function numbers (as shown in the listings) and never use numbers directly. The reason for this is that other compilers may not use the same numerical values for bios() function numbers as used in this version of bios().

You may want to delete (or "comment out") all the #define macros which will not be used, so that they will not occupy unnecessary space in the compiler's macro substitution table.

After compilation, bdos() and bios() will assemble under CP/M's ASM, The Software Toolworks' AS, and most other 8080 assemblers. Both functions may be assembled for nonstandard versions of CP/M by changing the CPBASE equate from 0 to the required value.

If you should want to delete the bdos() function and make a separate function of bios() only, you need to include the CPBASE equate in front of the bios() assembly code. To use bdos() and bios(), refer to the CP/M Interface Guide and the CP/M Alteration Guide.

A final warning: You should avoid direct CP/M calls whenever possible. Even though they enable you to do wonderful things in CP/M, they will limit the portability of your programs.

The code may be copied, used, and distributed by anyone, commercially or otherwise, provided the contribution notice is included.

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(Listings begin on page 24)

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c-systems

The following is an excerpt from a typical c-window debugging session. The ">>" is the c-window prompt, and the underscored text is the operator input. The text on the right is a brief description of the operations taking place.

```
entry at main line 15
>>bs addline, 58
>>g
break at addline line 58
>>d ptr
bae
>>d ptr = root
f02
>>d ++ptr
f14
>>ds ptr->symname
xyzzy
>>cs 1 d i

>>s
step at addline line 59
<1> d i
11
>>d i==1
1
>>bx addline,2,i<j&& k==0.
```

- c-window entry prompt showing function name and line number
- A breakpoint is set in function addline, line 58.
- The "go" command starts execution.
- The breakpoint is reached.
- The value of variable "ptr" is displayed.
- The variable "ptr" is set to the value of the variable "root".
- The variable "ptr" is incremented to the next entry in the table.
- Display the string at the member "symname" in the structure pointed to by "ptr".
- Command set. The variable "i" will be displayed for each break in execution.
- Single step.
- c-window displays the next line to be executed.
- c-window executes the automatic command, showing the value of "i" to be 11 hex.
- Test if "j" has the same value as "i".
- They are equal.
- Set an expression break. Once execution begins, c-window will break execution on the second occurrence of the expression "i<j&& k==0" evaluating non-zero in the function "addline".

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HL=HL+DE;	DAD D
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THEN	JNZ L1
A=A-14	SUI 14
ELSE	JMP L2
A=L;	L1:MOV A,L
M(BC)=A;	L2:STAX B

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BDOS and BIOS Calls for C

Listing One (Text begins on page 22)

```
*****  
*  
* CP/M BDOS- AND BIOS- CALLS FOR C/80  
*  
* Contributed by T. Bolstad, ELEKTROKONSULT AS  
* Konnerudgaten. 3, N-3000 Drammen, NORWAY.  
*  
* Date: January 17, 1983.  
*  
*****
```

/* DEFINITION OF BDOS FUNCTIONS */

```
#define RESET 0 /* SYSTEM RESET */  
#define CONIN 1 /* CONSOLE INPUT */  
#define CONOUT 2 /* CONSOLE OUTPUT */  
#define READIN 3 /* READER INPUT */  
#define PUNOUT 4 /* PUNCH OUTPUT */  
#define LISTOUT 5 /* LIST OUTPUT */  
#define DIRCON 6 /* DIRECT CONSOLE I/O */  
#define GETIOP 7 /* GET I/O BYTE */  
#define SETIOP 8 /* SET I/O BYTE */  
#define PRNTST 9 /* PRINT STRING */  
#define READCB 10 /* READ CONSOLE BUFFER */  
#define GETCST 11 /* GET CONSOLE STATUS */  
#define RETVN 12 /* RETURN VERSION NUMBER */  
#define RESDSK 13 /* RESET DISK SYSTEM */  
#define SELDISK 14 /* SELECT DISK */  
#define OPENF 15 /* OPEN FILE */  
#define CLOSEF 16 /* CLOSE FILE */  
#define SRCHFF 17 /* SEARCH FOR FIRST */  
#define SRCHFN 18 /* SEARCH FOR NEXT */  
#define DELF 19 /* DELETE FILE */  
#define RDSEQ 20 /* READ SEQUENTIAL */  
#define WRSEQ 21 /* WRITE SEQUENTIAL */  
#define MAKEF 22 /* MAKE FILE */  
#define RENF 23 /* RENAME FILE */  
#define RETLV 24 /* RETURN LOGIN VECTOR */  
#define RETCD 25 /* RETURN CURRENT DISK */  
#define STDMA 26 /* SET DMA ADDRESS */  
#define GETAA 27 /* GET ALLOCATION ADDRESS */  
#define WPDSK 28 /* WRITE PROTECT DISK */  
#define GETROV 29 /* GET READ/ONLY VECTOR */  
#define SETFAT 30 /* SET FILE ATTRIBUTES */
```

```

#define GETDPA 31 /* GET DISK PARAMETERS ADDRESS */
#define SGUC 32 /* SET/GET USER CODE */
#define RDRAN 33 /* READ RANDOM */
#define WRRAN 34 /* WRITE RANDOM */
#define COMFS 35 /* COMPUTE FILE SIZE */
#define SETRRC 36 /* SET RANDOM RECORD */
#define RESDRV 37 /* RESET DRIVE */
#define WRRZF 38 /* WRITE RANDOM WITH ZERO FILL */

bdos(func, arg) /* corresponds to bdos((BC), (DE)) */
int funct, arg;

/* CALL EXAMPLE: bdos(RETvn, 0)
BOTH ARGUMENTS MUST BE SPECIFIED !
Values are returned IN HL. BDOS errors
are returned as -1. */

```

```

{
#asm
CPBASE EQU 0 ;NORMAL 0-ORG'ED CP/M
CPNTRY EQU CPBASE+5 ;BDOS ENTRY

POP H ;GET RETURN ADDRESS
POP D ;GET ARG (INFORMATION ADDRESS)
POP B ;GET FUNCTION NO.
PUSH B ;RESTORE STACK
PUSH D
PUSH H

PUSH B ;SAVE FUNCTION NO. ON STACK
CALL CPNTRY ;BDOS CALL
XCHG ;SAVE HL IN DE
MOV L,A ;SAVE A IN L
;SIGN EXTENSION TO H:
RLC ;GET SIGN BIT INTO CY
SBB A ;IF CY=0, RESULT AFTER SBB IS ZERO
;IF CY=1, RESULT AFTER SBB IS -1 (IE ALL ONES)
MOV H,A ;NOW A IS MOVED TO HL WITH SIGN EXTENSION
POP B ;GET FUNCTION NO IN BC
MOV A,C ;GET FUNCTION NO IN A

CPI 12 ;WAS IT 'RETURN VERSION NUMBER' ?
JZ RETHL1
CPI 24 ;RETURN LOGIN VECTOR ?
JZ RETHL1
CPI 27 ;GET ALLOCATION ADDRESS ?
JZ RETHL1
CPI 29 ;GET READ/ONLY VECTOR ?
JZ RETHL1
CPI 31 ;GET DISK PARAMETER ADDRESS?
JZ RETHL1
JMP BDOSRET
}

```

(Continued on next page)

BDOS and BIOS Calls for C

Listing One (Listing continued, text begins on page 22)

```
RETHL1: XCHG  
BDOSRET: RET ;WITH RETURNED VALUE IN HL  
  
#endasm  
}  
  
/* DEFINITION OF BIOS FUNCTIONS */  
  
#define BOOT 0 /* COLD-BOOT */  
#define WBOOT 1 /* WARM-BOOT */  
#define CONST 2 /* CONSOLE STATUS */  
#define CONIN 3 /* CONSOLE INPUT */  
#define CONOUT 4 /* CONSOLE OUTPUT */  
#define LIST 5 /* LIST DEVICE */  
#define PUNCH 6 /* PUNCH */  
#define READER 7 /* READER */  
#define HOME 8 /* HOME DISK DRIVE HEAD */  
#define SELDSK 9 /* SELECT DISK DRIVE */  
#define SETTRK 10 /* SET TRACK */  
#define SETSEC 11 /* SET SECTOR */  
#define SETDMA 12 /* SET DMA ADDRESS */  
#define READ 13 /* READ ONE SECTOR */  
#define WRITE 14 /* WRITE ONE SECTOR */  
#define LISTST 15 /* LIST STATUS */  
#define SECTRAN 16 /* SECTOR TRANSLATION */  
  
bios(funct,arg1,arg2) /* corresponds to bios(function, (BC), (DE)) */  
int funct,arg1,arg2;  
  
/* CALL EXAMPLE: bios(SETTRK,5,0)  
ALL 3 ARGUMENTS MUST BE SPECIFIED, even though  
the last one is only used by SELDSK and SECTRAN. */  
  
{  
#asm  
  
    POP D ;RETURN ADDRESS  
    POP H ;ARGUMENT 2  
    SHLD ARG2S ;SAVE IT  
    POP B ;ARGUMENT 1  
    XCHG ;GET RETURN ADDRESS INTO HL  
  
    POP D ;FUNCTION NO.  
  
    PUSH D ;RESTORE SP  
    PUSH B  
    PUSH B  
    PUSH H ;RESTORE RETURN ADDRESS  
  
    PUSH D ;SAVE FUNCTION NO. ON STACK  
  
    LXI H,O ;CALCULATE OFFSET ADDRESS FROM FUNCTION:  
    DAD D ; GET FUNCTION NO. (OFFSET) IN HL
```

```

DAD    H      ; 2*OFFSET
DAD    D      ; 3*OFFSET
XCHG

LHLD   CPBASE+1 ; GET POINTER TO BIOS WBOOT ENTRY
DCX    H      ; DECREMENT TO
DCX    H      ; POINT TO
DCX    H      ; START OF BIOS ENTRY JUMP TABLE

DAD    D      ; ADD OFFSET (RESULT IN HL)
XCHG
LXI   H,RET1
PUSH  H      ; SAVE RETURN ADDRESS ON STACK

LHLD   ARG2S  ; GET ARGUMENT 2
XCHG
          ; GET ARGUMENT 2 INTO DE
          ; AND BIOS FUNCTION ENTRY ADDRESS INTO HL

PCHL

RET1: XCHG
      ; SAVE HL IN DE
MOV   L,A

RLC
      ; GET SIGN BIT INTO CY
SBB   A      ; IF CY=0, RESULT AFTER SUBB IS ZERO
              ; IF CY=1, RESULT AFTER SUBB IS -1 (IE ALL ONES)
MOV   H,A
POP   B      ; GET BIOS FUNCTION NO. IN BC
MOV   A,C
CPI   9      ; SELECT DISK FUNCTION ?
JZ    RETHL2
CPI   16     ; SECTOR TRANSLATION FUNCTION ?
JZ    RETHL2

JMP   RETBIOS
RETHL2: XCHG
      ; RETURN VALUE IN HL
RETBIO: RET
ARG2S: DS    2

#endif
}

```

End Listing One

Listing Two

```

#include "cpmcall.c"
main()
{
    bios(CONOUT,bdos(RETCD,0)+'A',0);      /* print current disk */
}

```

End Listing Two

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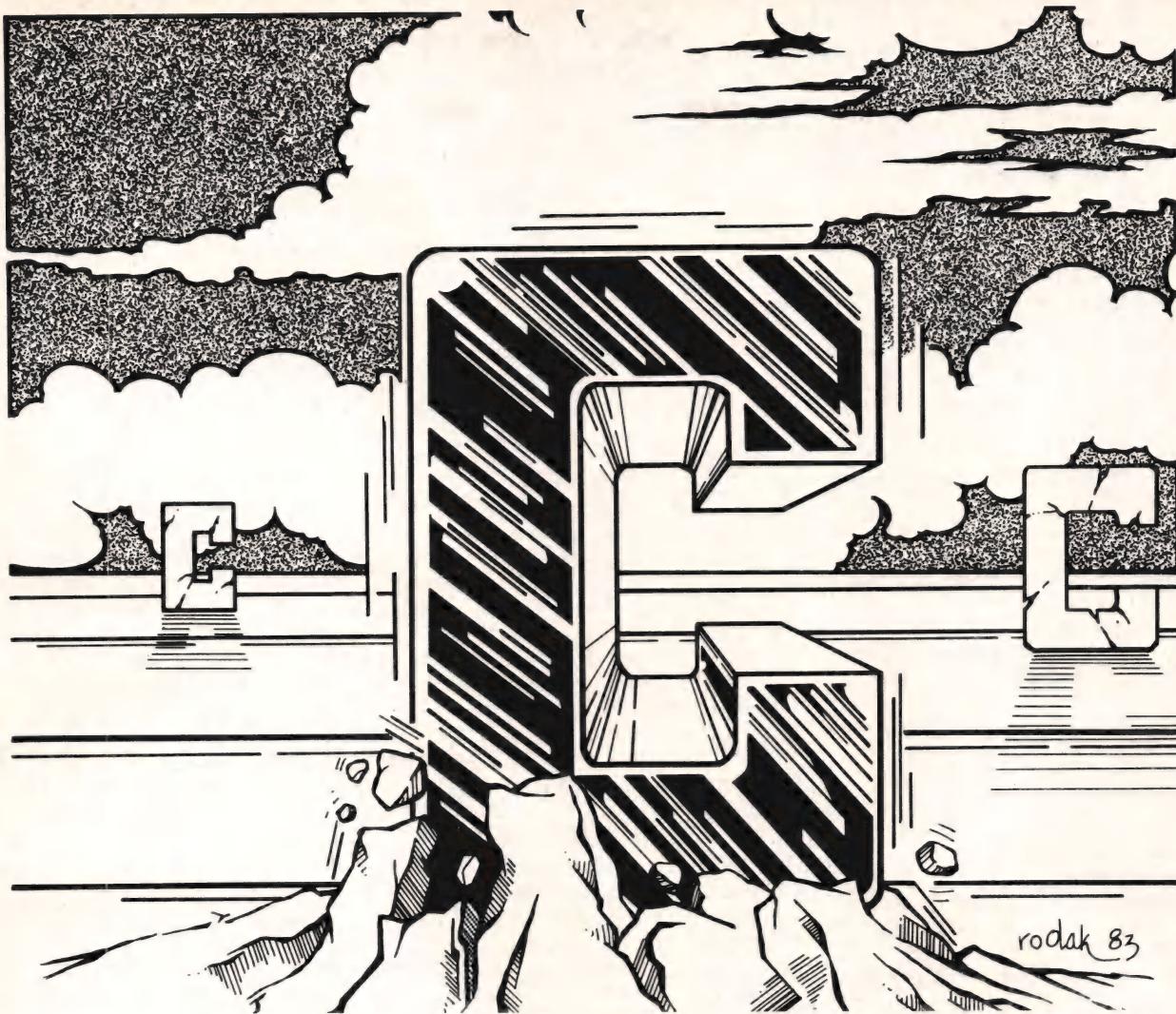
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Printing Graphics Using the IBM PC

The combination of the Color/Graphics Adapter and a printer capable of "dot graphics" provides a powerful utility function. The figure on page 36 shows an example of the image produced. PC-DOS at levels v.1.0 and v.1.1 does not provide direct support for this function. As this article is being written, v.2.0 was announced. I've heard that the new release corrects this omission, but my local suppliers can't supply v.2.0 as yet, so I'll ignore this new capability. All references to PC-DOS in this article should be assumed to refer to v.1.0 or v.1.1.

I've attempted to keep this at a "general" level, so that those of you who have "different" hardware may use the information to write your own utility. Specifically, however, the article (and included listing) is written for the standard IBM Color/Graphics Adapter and the original IBM Printer (EPSON MX-80) with the GRAFTRAX PLUS ROM installed! As I'm sure many of you are aware, the MX-80 produces quite variable results depending upon which control ROM is installed. The Graphics printer, provided on later models, should also work "as is," but minor adjustments may be required.

To introduce the "solution," it is first necessary to define the problem. In its simplest form, the problem is that of mapping. The color/graphics regeneration buffer contains a bit-encoded form of the displayed image. Dot matrix printers also use a bit-encoded form of the image to be printed. As you might expect, the two encoded forms are not even similar. The requirement for this utility, then, is simply that of mapping one bit-encoded form to another. Of course, before mapping can be performed, it is first necessary to understand the "rules" for encoding in both the input and output forms.

by Dan Daetwyler

Dan Daetwyler, Route 5, Box 518A, Springdale, Arkansas 72764.

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Display Regeneration Buffer Format

For detailed specification of the input form, you are referred to the *IBM Technical Reference Manual* for the PC. This article considers only the medium-resolution graphic mode, and includes the basic information that describes the bit stream used in this mode. In this mode the addressable unit is the "pel," and the screen image is composed of 64,000 pels. The pels are "compressed" so that each byte of the buffer contains four pels, hence the regeneration buffer size is 16,000 bytes. Due to the compression, each pel must be two bits in size, giving four possible bit patterns (0 through 3). The zero pattern indicates the "background" color, while patterns 1 through 3 indicate which of the three possible "foreground" colors has been selected. Palette selection and background color selection are not germane to this article, so I'll ignore them.

So far, this encode seems simple. You need only visualize a string of bytes which are associated with the screen positions. The first byte of the buffer is the upper left corner of the screen. The four pels corresponding to the first four dots (left to right) at the upper left corner of the screen are in this byte. The second byte contains the next four dots, etc., until 320 dots have been defined (80 bytes). Unfortunately, this simple and straightforward representation now breaks down. The second row of dots on the screen is not the next 80 bytes of the buffer, but rather is the 80 bytes at an offset of 8000 in the buffer. The regeneration buffer is organized into two blocks or banks of 8000 bytes each. I won't bore you with the rationale behind this organization, since it's purely related to hardware design and addressing. From our viewpoint it's sufficient to know that even-numbered rows are stored in the first bank, while odd-numbered rows are in the second bank.

To summarize, medium-resolution graphic images appear in the regeneration buffer as they appear on the screen, left to right, top to bottom, but the pels are compressed four to a byte, and alternate rows are stored in alternate banks.

Print Line Buffer Format

Dot matrix printing, on the other hand, considers a print "line" to contain eight rows of dots, left to right, top to bottom. The most significant bit of each byte corresponds to the top row of dots

in the print line. The printer used for the program provided offers two forms of dot matrix print: normal and high density. High density gives maximum resolution, so that was chosen. When operating in dot matrix, high-density mode, the printer will record 960 columns in the maximum print line (a column is a "dot"). Although one could map the graphic screen on a pel-to-dot basis, the image would be small, and no simulation of color would be possible. Since the maximum screen line contains 320 pels, dividing 960 by 320 gives us three dots per pel available. A little experimentation or computation shows that using a vertical dimension of two gives an image result that approximates screen proportion. Our mapping function, then, will map a pel to a 3x2 dot matrix. This also permits control of the dot density in this matrix to simulate color. Mapping for 100% density gives a very dark pel, while mapping for 30% density gives a light pel.

Now we can rough out the mapping function required. It must select pels from the regen buffer, by unpacking. These pels must be mapped to the corresponding 3x2 position in the printer buffer (left to right). The mapping function must also determine the row number of the pel and select from either the first bank of the buffer for even-numbered rows or the second bank for odd-numbered rows.

Program Description

Having determined the method of mapping, let's look at one program (see listing on page 38) that uses this scheme. PRTGRPH is a small, totally self-contained utility that will perform this mapping. It is written to produce a ".COM" file, since such a file is easier to patch if a change in control streams is required. The constants and data areas are given at the start of the program, but we'll skip over all of them initially.

The program proper starts with the control procedure, PRTGRPH. Initialization consists of setting the extra segment register to the segment address of the regen buffer (OB800H), and using standard DOS functions to prompt for (and accept) a title. The title is then "terminated" by a "\$" and left in the title save area, LBUF, for later use. The printer is initialized by output of the control stream, LSPC. For the standard GRAF-

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TRAX PLUS ROM, the printer control string:

Escape, A, 8

sets the printer to a line height of 8/72 inches. If you're using a different ROM, this control stream must be modified to match your ROM. A little experimentation using DEBUG to modify the control string should allow you to determine the proper line spacing for your printer.

Initialization is completed by setting the line count register (CX) to 50 (twice the lines on the screen), and the regen buffer register to a zero offset (SI). The main process loop at GRP1 is then entered. The call to PUTLNE will cause one print line to be generated and printed. The buffer register is stepped to the offset (start) of the next four display lines to be printed,

and the process loops when the line count is zero. The remainder of the code in PRTGRPH simply restores the printer to normal spacing and mode, prints the saved title, and restores the printer page to the start of the next page.

The next procedure, PUTPRT, simply puts a string (terminated by a "\$") to the printer. The code makes the function obvious, and I won't waste space describing this procedure.

PUTLINE clears the print buffer, builds the dot image, and then prints it. It's called once per line and is inserted in the program flow to preserve the entry values of the line counter and the regen buffer register. Useful work is performed by CLRBUF, BLDLNE, and PRTLNE which are called by this procedure.

CLRBUF again is a straightforward routine that simply pre-sets the printer buffer to binary zeros. PRTLNE simply prints the buffer, but in this case, it initializes the printer for dot matrix printing. This is done by output of the string BGRPH, which for the utilized ROM is:

Escape, L, 192, 3

This cryptic string tells the printer to enter high-density ("L") print mode for a line length of $192 + (3 * 256)$, or 960 dots. This re-initialization is required for each line, since the printer simply enters and stays in dot matrix mode for the byte count defined by this line length. It then returns to the mode it was in when it started the process.

BLDLNE is the basic mapping function. It begins by setting the print buffer register (DI) to zero, and an internal loop counter (BX) to the number of bytes in the line (80). A two-bit mask (0COH) is set in the DH register, and the inner loop counter (CH) is set in the outer loop, OLP. The inner loop, ILP, begins by clearing the shift count (CL) and loading the first regen byte for this print line into the AL register. This byte is masked by the content of DH and the result tested for zero. If zero, this pel is background color and is skipped. If non-zero, the call to SAVPEL is executed. In either case, the logic flow picks up at PEL2 which steps the shift count by 2 and loads the next regen data byte.

SAVPEL, which will be discussed in more detail later, simply fills in the 3×2 matrix with a dot pattern suitable for the color code determined by this masking process. Since the print line image is being built a pel at a time, left to right, the code at PEL2, PEL3, and PEL4 loads data from the appropriate bank of the regen buffer, and at the appropriate offset. Consider the first use of the routine. The SI register contains zero on entry, so the regen data load at ILP is of the first byte of the regen buffer, which corresponds to the first three dots in the first two rows of the print line (3×2 matrix again). The load at PEL2 is for the second two rows of the dot matrix print line, which correspond to the second row, first byte of the displayed image. It therefore is an odd-numbered row and must load from the second bank of the regen buffer (SI+2000H). The load at PEL3 is back to an even-numbered row, but it is now the third row of the displayed image (row 2 when considering zero as the first row), and must load from the first bank, second line, or offset 50H (80 characters into the buffer). The load at PEL4 follows the same logic, but it is again an odd-numbered row so the loading offset is 2050H.

Reaching STP, the code has completed the first three columns of the print line (eight rows), so the print buffer register

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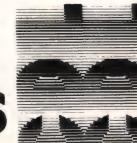
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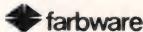


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is stepped by three. The mask is shifted to the next pel position, and the inner loop count decremented. This inner loop will execute four times (for the four pels in the screen byte), and then exit to a step of the regen buffer register, moving to the next four pels. The outer loop counter (BX) is decremented, and the process continues until 80 regen buffer bytes have been processed. This corresponds to one display line, and the build function exits.

To complete the code description, SAVPEL simply converts the color code masked from the pel to a dot matrix code of suitable density and stores this code in the print line buffer. You'll note that the mask saved in the print line buffer is saved in a two-bit space (the two part of the 3x2 matrix) and is saved in three bytes (the three part). Since we don't know in which two-bit field the pel is located in this procedure, the test checks all four two-bit fields. It checks first for the presence of a "one bit" in the two-bit fields. If not found, it assumes that the color code is a two, since the routine would not be entered if the color code is zero. If a one bit is found, then a two bit is checked. If not found, the color code is one, while if found, the color code is

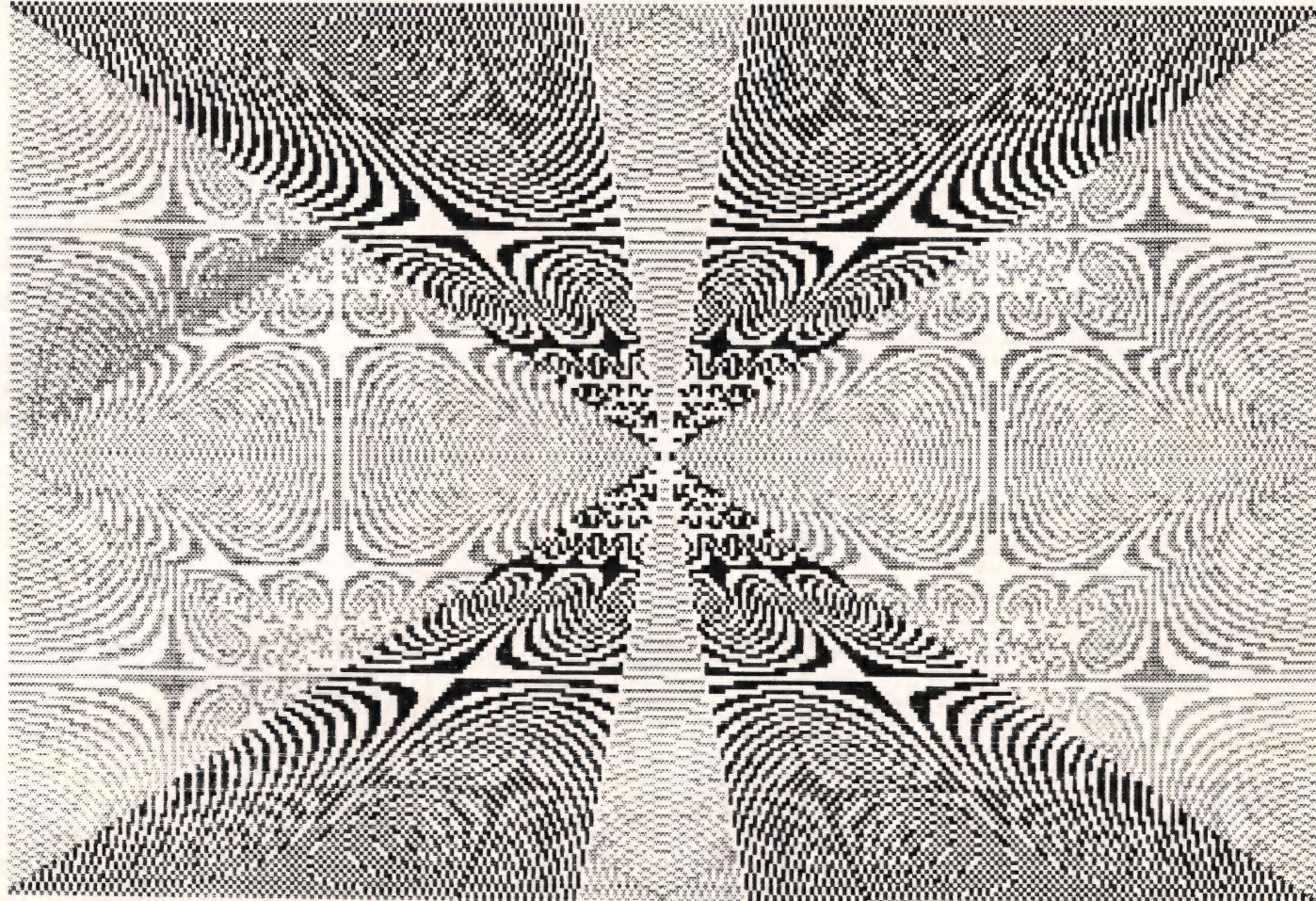
three. The DL mask and the CL shift may be modified to give different shade patterns. The one provided in the code seems to give a good contrast between colors, yet provides a pleasing overall density. You can try other combinations and select the one most suited to your printer (and your eye).

That's it. The listing is relatively well commented, so try reading through the code if this description doesn't seem clear.

Assembly and Link

Key in the source code as shown in the listing, and assemble using either of the assemblers. If you have a different printer or control ROM, you should change the printer control strings to match your configuration. Link as you would any other program. The link will respond with a "warning" message informing you that there is no stack segment and will give an error count of one. Ignore this error message and execute EXE2BIN. Rename the resultant file "name.COM" and execute.

For those of you who are operating at PC-DOS v.1.0, you may not have the DOS utility EXE2BIN, which is almost necessary to produce a ".COM" file. You



Kaleidoscope

Figure 1

may, therefore, prefer an ".EXE" file. If so, you must add a stack segment, initialize your data segment register, initialize the stack for the eventual return to DOS, and change the PRTGRPH procedure to a "FAR."

Use of the Utility

Use of the utility is primitive, with one big "hooker." The utility will print the content of the color/graphics regeneration buffer, *at the instant of execution*. How you invoke this utility without disturbing this buffer is a function of how you're configured. I'm working with both the monochrome and the color/display adapters, so it's easy for me. I simply arrange my graphics program so that it does *not* clear the graphics screen on exit, and switches back to the monochrome display before exit. That leaves the graphics regen buffer containing the image I want, and I can enter the command to execute this utility on the monochrome display. If you have only the color/graphics adapter, you'll have to be considerably more complex in your process. One trick is to include code in your display generation program that writes the entire regen buffer to disk under some condition. This utility can then be simply modified to load the buffer image into memory and point to it instead of the regen buffer.

Finally, this program is hereby placed in public domain. You may copy it, utilize it in your own work, etc. freely and without notification.

Although this utility is small and not too much keying is required, I will provide copy service. A single-surface diskette and a check for \$5 will get you a copy of the program source materials, object file, and an executable ".COM" file. A check for \$7.50 will get you a new Verbatim (or equivalent) containing the same materials. I'll furnish the return mailer and will ship UPS Blue Label unless otherwise instructed. Send to: Dan Daetwyler, Route 5, Box 518A, Springdale, AR 72764 (that's Arkansas, not Arizona).

If you have trouble/questions with this one, you can write me at the above address, or call 501-756-0212. (I'm usually around 24 hours, seven days.) Good luck and happy printing.

DDJ

(Listing begins on page 38)

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Printing Graphics on the IBM PC (Text begins on page 32)

```
COMMENT \
*****
* Copyright 1983 - DD Systems - Springdale, AR
*****
*
* Output Color Graphic Screen to Printer
*
* This self-contained utility maps the "pel" maps of the color graphic
* refresh buffer to the printer. It assumes the image has been
* loaded by other services.
*
*****\

;
CODE SEGMENT PARA PUBLIC 'CODE'
ASSUME CS:CODE, DS:CODE
ORG 100H
BEGIN: JMP PRTGRPH
;

PRMPT DB      'Enter Title: $'          ;Prompt for title line
LSPC  DB      27,'A',8,13,10,'$'        ;Sets printer to 8/72" spacing
BGRPH DB      27,'L',192,3,'$'         ;Sets to hi-density dot graphics
NORM  DB      27,'@','$'              ;Resets to normal mode
CRLF  DB      13,10,'$'               ;
;
LBUF   DB      80                   ;Title buffer
DB      82 DUP (?)                ;Bit graphics buffer
PBUF   DB      960 DUP (?)           ;Bit graphics buffer
DB      '$'

;
PRTGRPH PROC NEAR
MOV AX,0B800H
MOV ES,AX
MOV DX,OFFSET PRMPT
MOV AH,9
INT 21H
MOV DX,OFFSET LBUF
MOV AH,10
INT 21H
MOV AL,LBUF+1
CBW
MOV SI,AX
MOV LBUF+2[SI],'$'
MOV SI,OFFSET LSPC
CALL PUTPRT
MOV CX,50
MOV SI,0
GRP1: CALL PUTLINE
ADD SI,160
LOOP GRP1
MOV SI,OFFSET NORM
CALL PUTPRT
MOV SI,OFFSET CRLF
CALL PUTPRT
MOV SI,OFFSET LBUF+2
CALL PUTPRT
MOV CX,31
GRP2: MOV SI,OFFSET CRLF
CALL PUTPRT
LOOP GRP2
MOV SI,OFFSET NORM
CALL PUTPRT
RET
;
```

```

PRTGRPH ENDP
;
;      Simple "put string" to printer
;
PUTPRT  PROC    NEAR
        PUSH   SI
        PUSH   DX
PPLP:   MOV    DL, BYTE PTR[SI]
        CMP    DL, '$'           ;Check for "end of string" mark
        JZ     PPDNE
        MOV    AH, 5
        INT    21H                ;DOS Printer call
        INC    SI
        JMP    PPLP
PPDNE:  POP    DX
        POP    SI
        RET
PUTPRT  ENDP
;
;      Output one graphic "line"
;
PUTLNE  PROC    NEAR
        PUSH   SI
        PUSH   CX
        CALL   CLRBUF             ;Clear bit buffer
        CALL   BLDLNE              ;Build dot image
        CALL   PRTLNE              ;Output line
        POP    CX
        POP    SI
        RET
PUTLNE  ENDP
;
;      Clear line buffer to null
;
CLRBUF  PROC    NEAR
        XOR    DI, DI
        MOV    AX, DI
        MOV    CX, 480
CBLP:   MOV    WORD PTR PBUF[DI], AX ;Clears line buffer to null
        INC    DI
        INC    DI
        LOOP   CBLP
        RET
CLRBUF  ENDP
;
PRTLNE  PROC    NEAR
        MOV    SI, OFFSET BGRPH
        CALL   PUTPRT              ;Set printer for dot graphic line
        MOV    SI, OFFSET PBUF
        MOV    CX, 960               ; and output bit stream
PL1:    MOV    DL, BYTE PTR [SI]
        MOV    AH, 5
        INT    21H
        INC    SI
        LOOP   PL1
        RET
PRTLNE  ENDP
;
;      Build dot graphic bit stream in buffer
;
BLDLNE  PROC    NEAR
        XOR    DI, DI               ;Dot buffer index
        MOV    BX, 80                ;Loop count for line
OLP:    MOV    DH, 0COH              ;Outer loop mask
        MOV    CH, 4                 ;Inner loop counter
        ILP:   XOR    CL, CL            ;Shift for pel save

```

(Continued on page 41)

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Although Disk Inspector runs only on Z80 CP/M systems, you can inspect and alter normal (non CP/M) Apple diskettes, as well. The disk drives may be single or double density, single or double sided.

Note: Disk Inspector requires an 80x24 screen on your CRT.

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"They want how much?!"

Printing Graphics on the IBM PC

(Listing continued, text begins on page 32)

```
        MOV     AL,BYTE PTR ES:[SI]      ;Get screen byte
        AND     AL,DH                  ;Mask
        JZ      PEL2
        CALL    SAVPEL                ;non-zero, so print blob
PEL2:   ADD     CL,2
        MOV     AL,BYTE PTR ES:[SI+2000H] ;Next row
        AND     AL,DH
        JZ      PEL3
        CALL    SAVPEL
PEL3:   ADD     CL,2              ;Stepping shift count
        MOV     AL,BYTE PTR ES:[SI+50H]  ;Row three
        AND     AL,DH
        JZ      PEL4
        CALL    SAVPEL
PEL4:   ADD     CL,2
        MOV     AL,BYTE PTR ES:[SI+2050H] ;Fourth row
        AND     AL,DH
        JZ      STP
        CALL    SAVPEL
STP:    ADD     DI,3              ;Step save buffer pointer
        SHR     DH,1
        SHR     DH,1              ;Reposition pel mask
        DEC     CH
        JNZ     ILP                ;Continue inner loop for next col
        INC     SI
        DEC     BX
        JNZ     OLP                ;Step regen buffer ptr
        RET
BLIDLNE ENDP
;
; Save bit image for this pel - different "shade" for each color
;
SAVPEL PROC NEAR
        TEST    AL,5SH                ;One bit on
        JNZ     ONEB
        JMP     DOTWO
ONEB:  TEST    AL,0AAH               ;Test for two bit
        JNZ     DOTHRE
; The following is for a data bit of 01
        MOV     DL,OCOH                ;Load mask
        SHR     DL,CL                 ; and position
        OR      PBUF[DI],DL
        OR      PBUF[DI+1],DL
        OR      PBUF[DI+2],DL
        RET
DOTWO: MOV     DL,80H
        SHR     DL,CL
        OR      PBUF[DI],DL
        OR      PBUF[DI+2],DL
        SHR     DL,1
        OR      PBUF[DI+1],DL
        RET
DOTHRE: MOV     DL,OCOH
        SHR     DL,CL
        OR      PBUF[DI+2],DL
        RET
SAVPEL ENDP
;
CODE ENDS
;
END    BEGIN
```

End Listing

The Game of Life

on the IBM-PC

Computer programs for running John Conway's Game of Life were quite popular a few years ago. The problem with these older simulations was usually their speed: a single generation on a ten-by-ten grid could take up to 90 seconds. Presented here is a version of the game for the IBM/PC computer. Features of this version are adjustable speed (with 2.7 generations/sec as a top speed), easy entry of the seed generation (via a screen-editor), and marking of cells due to be "born," and cells remaining alive each generation (as different from cells marked to die). This feature gives a better impression of fluidity on the grid.

This version requires only the IBM monochrome display to run, and will run under either MS-DOS or CP/M-86, since only calls to the IBM ROM are made.

Background

The Game of Life takes place on a square grid. Every cell on the grid can be either alive or dead. Every cell on the grid has eight neighbors. Each generation, every cell on the grid is evaluated. The cell will remain alive if it has two or three neighbors, or will die if it has less than two (from loneliness), or more than three (from overpopulation). An empty cell

will have a "birth" (a live cell will be placed there the next generation) if it has exactly three neighbors. The game was developed by John Conway in 1976.

The Program

The program is straightforward. When first run, the screen is cleared and the cursor is positioned in the center. The cursor may be moved by pressing the four arrow keys on the keyboard (Num Lock doesn't matter because the keyscan code is interrogated, not the ASCII code). A live cell may be deposited by depressing Ins, and a cell may be cleared by pressing Del. When the screen is complete, pressing Esc starts evaluation of the next generation.

The program stores the grid in the screen memory of the monochrome display. Associated with every displayable character on the screen are two bytes of memory, the low byte for the character displayed, and the hi byte for the display attributes (underlined, reversed, etc.). The program uses the attribute byte of every screen position as a second array to hold the next generation in while it evaluates the present generation.

After the time delay, subroutine *count* is called. *Count* counts the number of neighbors that every cell has, and decides whether or not the cell will be alive in the next generation. If it is going to be alive, the display attribute for that character is set to *rev*. If the cell is going to be dead, the attribute is set to *dark*. *Rev* and *dark* are reverse video and normal video in my listing, so when a cell is going to

have a birth or stay alive, it is inverted on the screen, but *rev* and *dark* can be changed to three and five, causing both to display as normal if the flickering this produces is annoying.

After all of the decisions regarding life and death are made, subroutine *update* goes through screen memory putting in the character for a live cell if the cell is supposed to be alive, or a dead cell if the cell is supposed to be dead, and resetting the attribute byte.

The program then looks for a user key press. If one has occurred, the program quits if it was an Esc, or changes the time delay value if it was a digit. Pressing 0 gives no delay, or about 2.7 generations per second. Pressing 9 gives a 3.5 second delay per generation.

Expansions

The one problem with this implementation is that the screen doesn't have enough rows to allow a simulation of a complex colony. I would love to see an implementation of life in medium-resolution color graphics, with births in blue and deaths in red, but I don't have access to a color display, so that will have to wait. The program could also be cleaned up to make it run faster, but 2.7 generations a second is really fast enough for most applications.



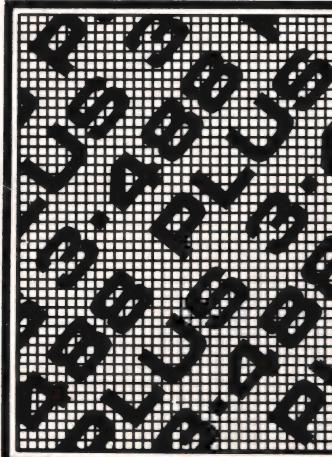
(Listing begins at right)

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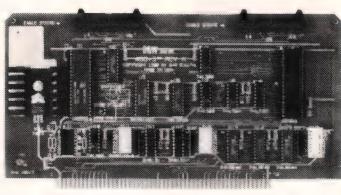
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Game of Life (Text begins on page 42)

Comment \$

```
*****  
*  
*      The Game of Life  
*  
*****
```

John Conway's mathematical game of life, implemented on the IBM/PC, by Simson L. Garfinkel.

Written in 8088 assembly language using the Microsoft Macro Assembler.

Notes on running the program:

When program is run:

1. Screen clears.
2. User enters first generation from keyboard.
Arrow keys move the cursor. INS key deposits a live cell, DEL removes a live cell, (in case the user makes a mistake.)
3. Pressing ESC starts program.
4. For each generation, cells which will have life on the next turn are inverted.
5. Screen is updated to next generation.
6. Keyboard is interrogated for command.
7. If ESC is pressed, program terminates.
8. If a number 0-9 is pressed, speed is selected.
At speed 0, approx. 2.7 generations/sec are performed
At speed 9, each generation takes 3.5 sec.
9. program loops to #4.

\$

; global definitions

```
live    equ  02          ;character for a live cell  
dead    equ  00          ;character for a dead cell  
  
rev     equ  70h         ;reverse video (marks cell to live)  
dark    equ  2           ;normal video  (marks cell to die )  
  
time   equ  300         ;time delay base  
  
TERM    equ  27          ;Character to exit mode  
  
  
cseg    segment para public 'code1'  
start   proc far  
        assume cs:cseg,ds:nothing,ss:stack,es:nothing  
  
                ;set up return location
```

(Continued on next page)

Game of Life (Listing continued, text begins on page 42)

```
push ds
sub ax,ax
push ax           ;now I can go home when I'm finished.

call Enter        ;Enter board
mov cx,0          ;initial delay, 0
main:
push cx           ;save delay variable
cmp cx,0
jz s13

s1:   push cx
      mov cx,time
s11:  push cx
      mov cx,time
s12:  loop s12
      pop cx
      loop s11
      pop cx
      loop s1       ;what a time delay!

s13:  call count    ;Count up every cell's neighbours,
      call update   ;Update screen
      pop cx         ;get back the time delay

      mov ah,1        ;See if user has pushed a key
      int 16h
      jz main        ;nope - loop back

      mov ah,0        ;get the character our of the buffer
      int 16h

      cmp al,TERM
      jnz s2
      ret            ;finished - go back to ms/dos

s2:   cmp al,'0'     ;see if it is a speed command
      jb main
      cmp al,'9'
      jnbe main
                  ;It's a number
      sub al,'0'     ;now it goes from 0 to 9
      mov ah,0
      mov cx,ax       ;put it in cx
      jmp main

start endp
```

```
Enter proc near      ;Subroutine to enter board
                    ;define scan-codes:
left   equ 75
right  equ 77
up    equ 72
```

```

down    equ   80
point   equ   82
del     equ   83
esc     equ   1

        call cls           ;clear the screen

;Registers are used as follows:
;DH - Y position
;DL - X position

        mov   dh,12
        mov   dl,40

e1:    mov   bh,0           ;move the cursor to x,y position
        mov   ah,2           ;code for cursor move
        int   10h           ;interrupt for cursor move

        mov   ah,0           ;set up to read the next keypress
        int   16h           ;keypress read

        cmp   ah,left        ;make a rational decision about the users
        jz   go_left         ;entry.
        cmp   ah,right
        jz   go_right
        cmp   ah,up
        jz   go_up
        cmp   ah,down
        jz   go_down
        cmp   ah,point
        jz   go_point
        cmp   ah,del
        jz   go_del

        cmp   ah,esc
        jnz  e1              ;loop back - unknown command
        mov   dx,23*256       ;put the cursor at lower-left hand corner
        mov   ah,2
        int   10h
        ret                ;go back to caller

go_left:          ;move left if I can
        cmp   dl,0           ;in leftmost column?
        jz   e1              ;yes - go back
        sub   dl,1           ;no - subtract one
        jmp   e1              ;go back

go_right:         ;move right if I can.
        cmp   dl,79
        jz   e1
        add   dl,1
        jmp   e1

go_up:            ;go up if I can
        cmp   dh,0
        jz   e1
        sub   dh,1
        jmp   e1

```

(Continued on next page)

Game of Life (Listing continued, text begins on page 42)

```
go_down:           ; go down if I can
    cmp  dh, 24
    jz   e1
    add  dh, 1
    jmp  e1

go_point:         ; put a live dot where the cursor is -- don't move it
    mov  al, live
gp2:   mov  cx, 1
    mov  ah, 10
    int  10h
    jmp  e1           ; get next command

go_del:           ; delete character at cursor
    mov  al, dead
    jmp  gp2           ; let go_point do the rest
Enter  endp
```

```
Cls    proc near      ; Subroutine to clear the screen
    mov  ax, 6*256
    mov  cx, 0
    mov  dx, 24*256+79
    mov  bh, 2
    int  10h
    ret
cls   endp
```

```
Count  proc near      ; Subroutine to count up every cell's neighbours
; Registers used:
; DH, DL: Y, X of current cell being interrogated
; DS     : Base offset - into screen memory
; DI     : offset for character presently being looked at
;
; Outline for each character
; 1. Count up number of neighbours
; 2. If three neighbours, or if two and cell is live, put
;    a rev on the screen at the attribute position, else
;    put a dark
; 3. Go to next character
```

```
chk    macro  yy, xx
local  chi, offs
offs   equ    (xx+yy*80)*2
        mov    cx,[di+offs]           ; get byte to check
        cmp    cl, live             ; check to see if this cell is alive
        jnz    chi                 ; nope
        add    al, 1                ; yes - increase neighbour count
chi:
endm
```

(Continued on page 50)



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Game of Life (Listing continued, text begins on page 42)

```
        mov  ax,0B000H
        mov  ds,ax      ;offset value for monochrome display

        mov  dh,1       ;Start at 1,1 and go to 23,78
        mov  dl,1       ;to prevent wrap-around

c1:   mov  ax,160      ;get true offset from ds into screen memory
        mul  dh

        mov  cx,dx
        mov  ch,00      ;just get dl
        add  ax,cx
        add  ax,cx      ;ax:=(dh*80+dl)*2

        mov  di,ax      ;di:=ax
        mov  ax,0       ;ax will be used for neighbour counting

        chk  -1,-1     ;count number of neighbours
        chk  -1, 0
        chk  -1,+1
        chk  0,-1
        chk  0,+1
        chk  +1,-1
        chk  +1, 0
        chk  +1,+1     ;test all of the neighbours

        mov  cx,[di]    ;get byte to check
        cmp  al,3
        jz   give_life ;life if has 3 neighbours
        cmp  cl,live   ;is it alive?
        jnz  give_death;no
        cmp  al,2
        jnz  give_death;nope

        give_life:          ;make this one alive
        mov  ch,rev
        jmp  c2

        give_death:
        mov  ch,dark
c2:   mov  [di],cx      ;put back on the screen

        next_cell:
        cmp  dl,78      ;am I at the end of the X line?
        jz   c3
        add  dl,1      ;nope
        jmp  c1
c3:   mov  dl,1
        cmp  dh,23      ;am I at the end of the Y line?
        jz   c4
        add  dh,1      ;nope
        jmp  c1
c4:   ret             ;yes - go home!
Count Endp
```

```

Update proc near
    mov ax,0B000H
    mov ds,ax

    mov bx,24*80*2-2 ;loop through all of the screen but last line
u1:   mov cx,[bx]
    cmp ch,rev ;is it to live?
    jnz u2 ;no
    mov cl,live ;yes
    jmp u3

u2:   mov cl,dead ;no
u3:   mov ch,dark ;turn off reverse
    mov [bx],cx ;put it back on the screen
    sub bx,2 ;loop back until done with the screen
    jg u1
    ret ;go back to caller
Update endp
cseg ends

stack segment para stack 'stack'
db 30 dup('stack ')
stack ends

end

```

End Listing

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Series Expansion in Forth

Series expansions are widely used in computers to generate precision non-linear functions. The usual approaches to series implementation use a lot of constants. This results in much space being used for headers or for stuffing all the constants into arrays, which makes checking and adding more constants awkward. Also, the mechanics of computing each series varies — some have only even and others only odd exponents, some have all exponents, some begin with a constant and others do not, etc.

A different approach, which places coefficient-exponent pairs into an array while preserving readability and access, is shown in screens 38-43, at right. The algorithm is identical for all series, regardless of first-term constant or exponent pattern. This approach, like Dr. Eaker's Case statement, permits the programmer to concentrate on the results rather than on the mechanics.

The first goal is to compactly store the data, which consists of floating-point coefficients and integer exponents. SERIES-CONSTANTS expects on the stack the number of terms to be computed. It then allots space for this number (1 byte) plus 7 bytes per term — one byte for the integer exponent and 6 bytes for the floating-point coefficient. This arrangement limits the number of terms and the exponent to 256, which would seem adequate for most needs. A header is compiled for the assigned NAME and the number of terms is stored in the first byte of the allotted space.

Next, the coefficients and exponents are written in the eminently readable format shown in Screen 227 (on page 55) which puts them on the stack in the reverse of the order shown, with the smallest exponent on top. Screen 228 contains the code to obtain the proper sign and to reduce the angle to within less than 360°.

These constants and exponents are next loaded into the allotted space with the phrase "n NAME LOAD-CONSTANTS." The number of constants to be stored is checked against the number for which space was allotted, and the

Series Expansion

```
Screen # 38
0 ( Series Expansion Statement by W.C. Gates 11-21-82 )
1 O VAL NEXTADD F0 FVAL FACUM
2 O VARIABLE POWER O VARIABLE NEXTEXP
3 : OVARS F0 TO FACUM O POWER ! ; ( Zero FACUM, POWER )
4
5 ( NGET does z add ... z add n with add+1 in NEXTADD )
6 : NGET DUP 1+ TO NEXTADD C@ ;
7
8 ( n SERIES-CONSTANTS name defines the storage space for an )
9 ( array which contains [number of terms] [exp. of 1st term] )
10 ( [FP coefficient of 1st term] [exp of 2nd term][next coeff.] )
11 ( exponents rise monotonically, but gaps OK )
12 : SERIES-CONSTANTS
13 <BUILDS DUP HERE C! 7 * 1+ ALLOT ( for 6-byte floating- )
14 DOES> ; ( point numbers )
15 -->
```

```
Screen # 39
0 ( Series Expansion-- LOAD-CONSTANTS )
1 (
2 ( LOAD-CONSTANTS stores the pre-computed coefficients into the )
3 ( space allotted by SERIES-CONSTANTS. These coefficients must be )
4 ( on the stack already, together with the exponent for each )
5 ( Cn exp[n] C1 exp1 C0 exp0 n add ... for example)
6 : LOAD-CONSTANTS DUP 1+ TO NEXTADD ( store add of 2nd byte )
7 >R DUP R> ( DUP n under address )
8 C@ ?PAIRS ( fetch allotted n, QUIT if not same )
9 O DO ( DO n times )
10 NEXTADD C! ( store exponent at next byte )
11 NEXTADD 1+ TO NEXTADD ( point to next byte )
12 NEXTADD F! ( store coefficient )
13 NEXTADD 6 + TO NEXTADD ( point past stored coeff. )
14 LOOP ;
15 -->
```

```
Screen # 40
0 ( Series Expansion--continued )
1 ( TERM raises z to the power stated in the first byte of each )
2 ( term/constant location, starting with the value z^n of the )
3 ( previous term.
4
5 ( z z^n ... z z^{n+x} z^{n+x} , NEXTADD points to exp. )
6
7 : TERM
8   NEXTADD C@ NEXTEXP ! ( store target exponent )
9   BEGIN
10    POWER @ NEXTEXP @ = 0= ( current exp. = target exp? )
11    WHILE ( if not, )
12    FOVER F* 1 POWER +! ( raise exponent 1, inc. POWER )
13    REPEAT ( repeat until current=target, )
14   FDUP ; ( then FDUP and exit. )
15 -->
OK
```

by Wendall C. Gates

Wendall C. Gates, PE, Advanced Instrumentation Inc., Box 2070, Santa Cruz, California 95063.

Screen # 41

```

0 ( Series Expansion -- ADD-TO )
1
2 ( ADD-TO fetches the next coefficient and multiplies it with )
3 ( z^n on TOS, then adds result to FACCUM, and points      )
4 ( NEXTADD to exponent of next term. )                      )
5
6 ( z z^n z^n .... z z^n )
7
8 : ADD-TO
9  NEXTADD 1+ TO NEXTADD      ( point to coefficient      )
10 NEXTADD F0 F*             ( fetch and multiply x z^n   )
11 FACCUM F+ TO FACCUM       ( add to cumulative total   )
12 06 NEXTADD + TO NEXTADD ; ( point to exp. of next term )
13
14 -->
15

```

Screen # 42

```

0 ( Series Expansion-- SERIES    )
1 ( Used as z [name] SERIES ... for value z.                  )
2 ( number of terms is defined in [name] )                     )
3
4 : SERIES
5 OVARS >R F1 R>      ( set variables to 0, F1 to stack )
6 NGET 0 DO            ( get # of terms for loop      )
7     TERM ADD-TO ( calculate term and add to total)
8     LOOP
9 FDROP FDROP          ( drop calculation values      )
10 FACCUM ;            ( leave accumulated value on stack)
11 ;S
12
13
14
15

```

Screen # 43

```

0 ( SERIES expansion-- BY-N and BY-EXP , fetching/storing exp. )
1 ( BY-N leaves the address of the nth exponent-coefficient pair )
2 ( used as .... n NAME-CF BY-N followed by F0 or F!      )
3
4 : BY-N 2DUP @ >           ( test for n inside array )
5     IF CR ." n is outside array." QUIT ENDIF
6     2 + SWAP 7 * + ;        ( point to coeff. in nth term)
7
8 ( .. n NAME-CF BY-EXP leaves the address of coeff. with exp. n )
9
10 : BY-EXP NGET SWAP 0 FLAG ! ( n to TOS, add+1 to NEXTADD)
11     BEGIN DUP NEXTADD C0 = ( compare to term exp )
12     IF 1 ELSE OVER FLAG @ = ( no more than n terms )
13     IF CR ." Exponent not found." QUIT ENDIF
14     0 1 FLAG +! NEXTADD 7 + TO NEXTADD ENDIF ( next term )
15     UNTIL 2DROP NEXTADD 1+ ; ;S

```

OK

DDJ

exponent-coefficient pairs are stored into the space. Only one header is required for all the exponents and coefficients.

Computation is done by SERIES, which expects a floating-point value and the beginning address of the data space, left by NAME-CF of the series. The first byte is the number of terms, which is used as the DO-LOOP index. TERM raises the power of the base value until it matches the next stored exponent. ADD-TO fetches the matching coefficient, multiplies it with the raised base value, and accumulates the total in ACCUM. This sequence is repeated n times to generate and add up n terms. Exponents may increase in any monotonic pattern. A series in half-power exponents, frequently encountered in flow measurement, may be generated by taking the square root of the base value before using it to compute the series.

In some applications, adaptive control for example, it may be necessary to modify the series coefficients during operation. This feature is provided by BY-N, used as "n NAME-CF BY-N," which leaves the address of the n th coefficient in the series. The word BY-EXP similarly leaves the address of the coefficient of the term whose exponent is n .

Where evaluation of polynomial derivatives is required, a slower and less compact method is implemented, in Screens 45-49 (pages 53-55). The polynomial coefficients are transferred to a working array, with floating-point 0s inserted for the absent coefficients. This array is then processed by CALC.DERIVS, resulting in the coefficient values being replaced by the n derivative values, including the value of the polynomial itself in the first location. The values of the n derivatives are then fetched as required using N DERIV. For an explanation on the mathematical method, see the article by R.A. Hoffman in *Dr. Dobb's Journal*, April 1981.

The screens provided are written for a floating-point package which uses a 6-byte format for floating-point numbers. For 4-byte formats, change the 6s and 7s to 4 and 5. The floating-point coefficients are handled as groups of bytes, so the program is indifferent to the internal sign-exponent-mantissa format.

(Listing begins on page 52)

Reader Ballot

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Screen # 45

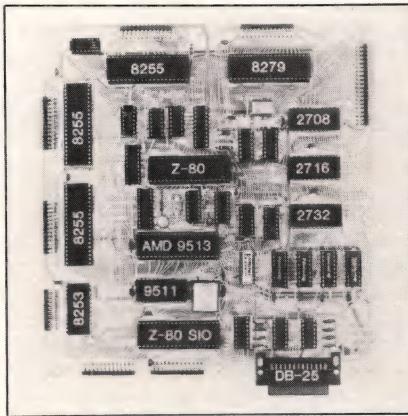
```

0 ( Derivative Calculations--N derivatives of n-order polynomial.)
1 ( Method from Hoffman, DDJ April 81, implm by W.C.Gates Dec 82)
2 FO FVARIABLE EVAL-POINT 0 VARIABLE POLY-ARRAY
3 : GEN.ARRAY

```

(Continued on next page)

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Series Expansion

(Listing continued, text begins on page 52)

```

4 10 DUP          ( highest anticipated order      )
5 HERE DUP POLY-ARRAY !   ( beg. address to POLY-ARRAY    )
6 C!               ( store highest order in 1st byte   )
7 1+ 7 * 1+ ALLOT ;   ( allot space for order+1 terms,
8                               ( each of which is exp-byte plus float# ) )
9
10 : GET.ORDER     ( expects add. of coef. array, fetches order,  )
11 DUP C0          ( which is exponent of last term, to TOS  )
12 1- 7 * 1+ +
13 C0 ;
14 GEN.ARRAY       ( allots array when LOADED.           )
15 -->

```

Screen # 46

```

0 ( Derivative Calculations -- FILL.ARRAY transfers coeff's from )
1 ( permanent array to working array, filling F0 for absent coeffs)
2 : FILL.ARRAY      ( poly-array-add coef-array-add .... )
3 DUP GET.ORDER    ( padd cadd n .... )
4 >R OVER R> DUP ROT C!   ( store order in 1st byte   )
5 >R 1+ SWAP 1+ R> 1+ 0   ( point to exp.bytes, loop n+1 times)
6 DO OVER C0 I =     ( print exp, test for equal exp's  )
7 IF DUP I SWAP C!   ( if =, move exp. )
8 1+ DUP 6 + SWAP ROT 1+ DUP 6 +   ( and calc. next add's )
9 ROT ROT SWAP >R
10 F0 R> F! SWAP
11 ELSE DUP 7 + SWAP
12 DUP I SWAP C!
13 1+ >R F0 R> F!   ( but try again at same loc in source)
14 THEN
15 LOOP 2DROP ; -->

```

Screen # 47

```

0 ( Derivative Calculation -- *FACS multiplies terms by n!      )
1
2 : *FACS          ( empty stack .... same )
3 F1 POLY-ARRAY @ DUP 16 + SWAP ( F1>stack, point to ^2 term)
4 C0 1+ 2          ( n+1, 2 = for 2 to n      )
5 DO
6 I SWAP DUP DUP >R >R >R ( I>stk, add's to ret. stk )
7 S->D D>F        ( convert I to floating #   )
8 F* FDUP R> F0 F*   ( x prev. "!", x coeff,   )
9 R> F!
10 R> 7 +
11 LOOP
12 DROP FDROP ;    ( leave stack clean      )
13
14 -->
15

```

OK

Screen # 48

```

0 ( Derivatives Calculation -- CALC.DERIVS performs calculations )
1 ( replacing coef's with values in working array.                )
2 : CALC.DERIVS      ( <point of evaluation--F#> <series-name...> )
3 >R EVAL-POINT F!   ( store X1 value to EVAL.POINT   )
4 POLY-ARRAY @ DUP R> ( work-add to stack, R> series-array-add)
5 FILL.ARRAY C0 DUP   ( coeffs into work-array, filling F0's  )
6 1- SWAP 0          ( ...N-1 N 0 )
7 DO DUP DUP I 1- SWAP

```

```

8      DO          ( limit is 1st index, index is )
9      I 1+ POLY-ARRAY @ BY-N F@      ( N-1 minus iteration # )
10     EVAL-POINT F@ F*            ( prev.coeff. x point value )
11     I POLY-ARRAY @ BY-N DUP >R    ( add above to current coeff)
12     F@ F+ R> F!
13     1- -1 +LOOP DROP
14     LOOP
15     *FACS ;      -->           ( each coef x n factorial)

```

```

Screen # 49
0 ( Derivatives Calculation-- DERIV fetches nth derivative value )
1 ( checks for out-of bounds request, non-destructively )
2 : DERIV
3 DUP POLY-ARRAY @ DUP
4 ROT SWAP C@ >
5 IF 5 SPACES ." Requested too high a derivative. " 2DROP
6 ELSE 2+ SWAP 7 * + F@
7 THEN ; ;S
8
9 USE OF DERIVATIVES CALCULATION
10 Define largest order polynomial to be used; add 1 to order and
11 insert this value into Screen 45, line 4. Then 45 LOAD.
12
13 <F#evaluation point> <series-coeff-name> CALC.DERIVS... does
14 the calculations, N DERIV puts the nth derivative value on
15 the stack.

```

OK

```

Screen # 227
0 ( Floating Point-- SINE )
1 6 SERIES-CONSTANTS SINE-CF          ( allot storage space )
2           ( coefficients           ) exponents
3
4 -2.50521084 X -8                  11   ( monotonically   )
5 2.75573192 X -6                  9    ( decreasing     )
6 -1.98412698 X -4                  7    ( exponents     )
7 0.33333333 X -3                  5
8 -1.66666667 X -1                  3
9 F1                               1
10 6 SINE-CF LOAD-CONSTANTS          ( n [name] LOAD-CONSTANTS )
11 : [SINE] SINE-CF SERIES ;
12
13 ( "X" is used for floating point entry to permit using "E" in)
14 ( reading hex keypads. F1 is 1.0 floating point. )
15 -->

```

```

Screen # 228
0 ( Trig Package -- SINE continued )
1
2 : ANGLE-PREP          ( convert to rads if rqd )
3 FPI F/MOD FABS FIX D->S ( get # of half circles )
4 DUP 0= IF DROP ELSE >R ( x -1, is - for 2nd half )
5 F1      R> 0 DO ( +1 for 1st, -1 for 2nd )
6 F1 FMINUS F* LOOP ( apply sign to angle <180 d. )
7 F* ENDIF ; ( calculate sine series )
8
9 : FSIN
10 DEG-RAD 0= IF DEG>RAD ENDIF ( using degrees? convert >rads)
11 ANGLE-PREP [SINE] ; ( strip full turns, calc. and )
12           ( apply sign, calc. value )
13 ;S
14
15

```

End Listing

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Fast Matrix Operations In Forth, Part 1

It is fairly well-known that among various languages having software-implemented floating point, there is little practical difference in the speed at which number-intensive programs run. The reason for this small difference is that a large proportion of total program run time is spent on the floating-point routines that are written in assembly language and are therefore essentially the same for every language. Since most languages developed under this condition, it is doubtful that any need for faster numerical operations influenced their evolution. With the advent of hardware-implemented floating point in the form of numeric coprocessors such as the 8087, 80287, and 16081, a situation arises in which most of the popular numerical languages are incapable of efficiently utilizing their speed. This deficiency is most true of interpreted languages such as BASIC and APL.

In my quest for a faster alternative, I have found what I believe to be an ideal in an unpopular floating-point language, Forth. More specifically, I have found PolyForth for the IBM PC to be best for floating-point applications because it uses the 8087 register stack as an extra Forth stack and it includes the 8087 instruction set in its assembler. By using the assembler, it is not unusual for a numerically intensive program to run 100 times faster in Forth than in standard BASIC.

From the viewpoint of programming convenience, APL is the Rolls Royce of numeric languages. The enthusiasm of APL users easily matches that of Forth users, although each group loves their language for entirely different reasons. APL is characterized by syntactically simple commands that operate on entire arrays rather than on single numbers. Generally, the shortest program for performing a given task can be written in APL. APL does, however, have a reputation for being slow.

I have found that it is not at all difficult to write Forth programs that resemble APL commands. For example, consider the following phrase for performing matrix multiplication in Forth:

' A ' B ' C A*

Here, A* is the matrix multiplication operator and A, B, and C are arbitrary conformable matrices. In algebraic notation, $C = AB$. The advantage of Forth over APL is, of course, speed. The program represented above will multiply two 10th-order square matrices in 0.1 seconds. APL users are invited to present benchmarks for comparison.

In this first of a three-part series, some fundamental Forth matrix utilities will be presented. In the second installment, programs for the classical matrix operations such as matrix addition, multiplication, and inversion, plus some equally useful but more unusual operations, will be presented. The third part will be concerned with matrix applications. If reader response is favorable, more items on matrix applications could be forthcoming.

These programs require: (1) the IBM PC with more than 64 KB, preferably 320 KB, of RAM; (2) an 8087 numeric coprocessor installed in the empty socket next to the 8088 (dipswitch SW1-2 must be off); and (3) PolyForth Level 2 for the IBM PC from Forth, Inc.

The Programs

The fundamental programs are presented in screens 207 to 209 (page 57). A description of these programs follows:

a!, a@, etc. — Fast concatenated 16-bit variable stores and fetches. These will be used within many of the succeeding programs.

matrix — Defines a character string as a matrix. Usage example:

10 20 matrix X

Here, X is defined as a matrix of 10 rows by 20 columns. Such a matrix has the following properties:

- The data contained in the matrix resides outside the Forth dictionary and can occupy all available memory beyond the first 64 KB segment of RAM.
- Two 64-bit numbers can be stored in each matrix element. Thus, X in the above example can be considered as two interlaced matrices of real numbers or a single matrix of complex numbers. Operators subscripted with 1 and 2 will respectively apply to the first or second of the two "interlaced" matrices,

whereas unsubscripted operators will apply to the matrix as a whole.

- Indexing of the matrix elements is from (0,0) to (m-1,n-1) where m is the number of rows and n is the number of columns.

variable — Defines a character string as a 16-byte variable outside the first 64 KB of RAM. Usage example:

variable Y

forget — Erases a matrix or variable in a manner analogous to the standard Forth word FORGET. Usage example:

forget X

dim@ — Retrieves the dimensions of the matrix and puts them on the parameter stack with the number of columns on top and the number of rows underneath. Usage example:

' X dim@

dim! — Changes the dimension of a matrix. The number of matrix elements, however, must not increase. Usage example:

200 1 ' X dim!

!1, !2, !! — Are matrix element and variable stores. !1 and !2 transfer the top number of the numeric stack to the indicated position in the matrix element or variable. !! is functionally equivalent to !2 !1. Usage examples:

3.14 5 15 X !1
2.72 1.23 Y !!

@1, @2, @@ — Are matrix element and variable fetches. Usage examples:

5 15 X @2
Y @1

EXC1, EXC — Are exchange matrix elements or variables. Usage examples:

5 15 X 3 2 X EXC1
Y 8 9 X EXC1

A few final notes: Because floating-point numbers and integers are stored on separate stacks, their order before an operator makes no difference. Thus, these phrases are equivalent:

123.456 654.321 3 7 X !!
3 7 123.456 654.321 X !!
3 123.456 7 654.321 X !!

Also, the use of ' should be commented on. This is called "tick" and it places the dictionary address of the word following it

by Steven A. Ruzinsky

Steven A. Ruzinsky, 2110 S. Austin Blvd., Cicero, Illinois 60650.

onto the parameter stack. ' is for use outside a colon definition. Inside a colon definition ['] must be substituted. ' and ['] are used extensively to pass subroutines.

Mr. Ruzinsky, in an attempt to demonstrate the floating-point speed that one can achieve with Forth, brought to our attention the article "Benchmarking the 8087 Numeric Coprocessor" in the March 1983 issue of Personal Computer Age. In it, G. Scott Owens provided some benchmarks for the IBM PC with an 8087 coprocessor (and some for the IBM and other machines without the 8087). The fastest times obtained for his floating-point routine (a mixture of various functions such as sine, cosine, and squareroot) were: IBM Pascal with an 8087 - 6 seconds; and compiled IBM BASIC with an 8087 - 10 seconds for single precision and 13 seconds for double precision. (The 8087 software in those cases was from Microware.) Mr. Ruzinsky wrote a Forth

```

316
0 ( FPBENCH in Polyforth, Double Prec., 2.625 sec./500 iters. )
1 ( Note: SIN, COS, EX, #IN, and 4ARRAY are author written )
2 ( routines that are not included in standard Polyforth. )
3
4 : 4ARRAY CREATE 8 * 10 + ALLOT :CODE W INC W INC O POP O SHL
5     O SHL O SHL W O ADD O PUSH NEXT
6     10 4ARRAY X LVARIABLE A
7 : LOOP2 10 I DO I X L@ FDUP F* PI F/ A L! LOOP ;
8 : SBR PI 2.1 F/ FDUP SIN 1 X L! FDUP COS
9     2 X L! FDUP FDUP F* 3 X L! FDUP FSQRT 4 X L!
10    FDUP EX 5 X L! FDUP LN 6 X L! FDUP 7 X L!
11    FDUP PI F* 8 X L! SIN 2.0 F* 9 X L! ;
12 : FPBENCH CR ." THIS IS A NUMBER CRUNCHING SPEED TEST "
13     CR ." ENTER THE NUMBER OF ITERATIONS " #IN
14     COUNTER SWAP O DO SBR LOOP2 LOOP COUNTER SWAP
15     ->N 1000.0 F/ CR ." ELAPSED TIME = " 3 F. ;

```

Figure 1.

Floating-point benchmark routine in Forth.

version on his own system of the floating-point routine used by Mr. Owens and obtained a time of 2.625 seconds. His Forth routine is printed in Figure 1 (above).

■DJ

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(Listing begins below)

Fast Matrix Operations (Text begins on page 56)

207 LIST

```

0 VARIABLE a           CODE a! O POP a STA NEXT
1                         CODE a@ a LDA O PUSH NEXT
2 VARIABLE b           CODE b! O POP b STA NEXT
3                         CODE b@ b LDA O PUSH NEXT
4 VARIABLE c           CODE c! O POP c STA NEXT
5                         CODE c@ c LDA O PUSH NEXT
6 VARIABLE i           CODE i! O POP i STA NEXT
7                         CODE i@ i LDA O PUSH NEXT
8 VARIABLE j           CODE j! O POP j STA NEXT
9                         CODE j@ j LDA O PUSH NEXT
10 VARIABLE k          CODE k! O POP k STA NEXT
11                         CODE k@ k LDA O PUSH NEXT
12 VARIABLE m          CODE m! O POP m STA NEXT
13                         CODE m@ m LDA O PUSH NEXT
14 VARIABLE n          CODE n! O POP n STA NEXT
15                         CODE n@ n LDA O PUSH NEXT

```

208 LIST

```

0 ( Matrix Defining Operators )
1 ~ VARIABLE (here) 1 (here) !
2 ~ : here (here) @ ;
3 ~ : forget -' ABORT" ?" B/H - DUP 'S H 2+ @ WITHIN
4             CAN'T H ! CURRENT CONTEXT 2+ DO I BEGIN
5             @ DUP HERE < UNTIL I ! 2 /LOOP @ (here) ! ;
6 ~ : allot here + (here) ! ;
7 ~ : variable here CONSTANT 1 allot ;
8 ~ : matrix CREATE here , SWAP 2DUP , , * allot ;CODE O POP
9             1 POP 2 W) 1 ADD 4 W) MUL 1 O ADD O PUSH NEXT
10 VARIABLE adr           ~ CODE adr@ adr LDA O PUSH NEXT

```

(Continued on next page)

Fast Matrix Operations (Listing continued, text begins on page 56)

```
11 ~ CODE adr! O POP adr STA NEXT
12 ~ CODE dim@ W POP W ) O MOV adr STA 2 W) O MOV O PUSH
13 4 W) O MOV O PUSH NEXT
14 ~ CODE dim! W POP W ) O MOV adr STA O POP O 4 W) MOV O POP
15 O 2 W) MOV NEXT
```

209 LIST

```
0 ( Matrix Element Fetch, Store and Exchange )
1 CODE !1 O DS SSG DS POPS R64 65520 FSTP O DS LSG NEXT
2 CODE @1 O DS SSG DS POPS R64 65520 FLD O DS LSG NEXT
3 CODE !2 O DS SSG DS POPS R64 65528 FSTP O DS LSG NEXT
4 CODE @2 O DS SSG DS POPS R64 65528 FLD O DS LSG NEXT
5 CODE !! O DS SSG DS POPS R64 65528 FSTP R64 65520 FSTP
6 O DS LSG NEXT
7 CODE @@ O DS SSG DS POPS R64 65520 FLD R64 65528 FLD
8 O DS LSG NEXT
9 ~ CODE EXC 65520 # W MOV O DS SSG DS POPS R64 8 W) FLD R64
10 W) FLD 2 DS SSG DS POPS R64 8 W) FLD R64 W) FLD 1 DS SSG
11 2 DS LSG R64 W) FSTP R64 8 W) FSTP 1 DS LSG R64 W) FSTP
12 R64 8 W) FSTP O DS LSG NEXT
13 CODE EXC1 65520 # W MOV O DS SSG DS POPS R64 W) FLD 2 DS SSG
14 DS POPS R64 W) FLD 1 DS SSG 2 DS LSG R64 W) FSTP 1 DS LSG
15 R64 W) FSTP O DS LSG NEXT
```

End Listing

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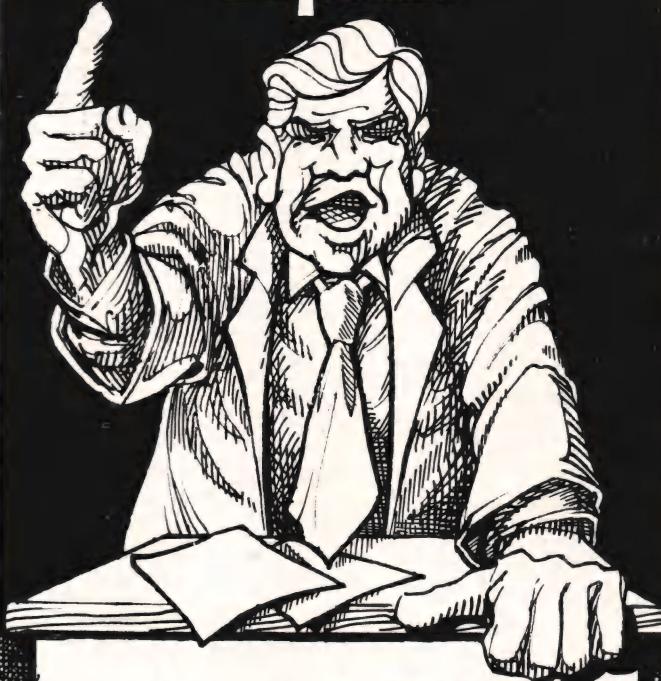
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Yes, You Can Trace Through BDOS

Letters to Dr. Dobb have shown an interest in using the DDT Trace function to examine the operation of BDOS functional calls. The last word on the subject (February 1983, page 11) was, "This will never work no matter how clever one is...." Who could resist a challenge like that?

Demonstrating the Problem

Let's try to Trace through a very simple BDOS function and see what the problem is. BDOS function 31 is a good candidate for this because it only fetches the disk parameter address and puts it in the H/L register pair. The test program (TRACE.ASM – shown in Listing 1 below) contains the minimum elements necessary to demonstrate the problem.

- (1) It initially clears the H/L pair (so we know the non-zero result was not left over from a previous run).
- (2) It calls BDOS function 31.
- (3) It executes an instruction (NOP) after it returns.
- (4) It has an easily recognized end.

The DDT session is separated into procedures to make it easier to follow.

In Procedure 1 (page 61), I booted a 48K system (system size is important) and used DDT to get the test program in memory. The List command disassembled the object code in memory, showing that the program was actually there. The Go command executed the program (from 100 to 108) and the Examine (X) command showed that the H/L pair had B47E in it when the test program was finished. B47E is in fact the address of the disk parameter header for this particular CP/M configuration. If you run this program on your system, you will probably get a different number in the H/L pair. If you are skeptical, you can examine memory beginning at that location and verify that it is actually a disk parameter header.

The G100,100 command gets the program counter back to the beginning of the program, and TOC is the command to Trace twelve lines (DDT thinks in hex). Notice that the H/L pair was cleared, Register C was set to 31 (1F hex), and the BDOS routine was called.

by Do-While Jones

Do-While Jones, 324 Traci Lane, Ridgecrest, California 93555.

Location 0005 always contains a jump to the BDOS section of CP/M. Since the location of BDOS depends upon memory size, this address will vary depending upon system size. Whenever you boot the CP/M system, it will always make sure the jump command at 0005 is set to the proper address. In the 48K system I was using, this address was 9500. The Trace display showed the jump to 9500, and the first few instructions in BDOS, but the line following JMP A506 shows a NOP. Closer inspection shows the program counter appeared to go from 9BA7 directly to 0108. I say "appeared" because the intermediate steps really were executed. We can tell this by the fact that the H/L pair has the right answer (B47E) in it.

The invisible gap between 9BA7 and 0108 is the sequence of instructions that some readers are interested in seeing.

To Trace or Not To Trace . . .

Although it is possible to Trace through BDOS, I do not recommend that you do it routinely. DDT is designed not to Trace through BDOS functions for

your convenience. If you defeat this feature frequently, you will just make your own life more difficult.

Inexperienced programmers use Trace at the first sign of trouble. They hit control-P, T100 and start looking through reams of paper that slowly emerge from the printer. That is not a very efficient way to debug a program, especially if it contains something equivalent to "FOR I = 1 TO 500."

The easier way to debug a program is to use break points. Use the "G" command to execute a small portion of the program. When DDT finishes executing that section, it will return with the "*" prompt, which is your cue to use "X" to examine registers or "D" to display memory. If you have written your program in modular form, there will be longer places to stop and examine the results. For example, if you have a module which is supposed to convert hex numbers into BCD form, then you can stop the program just before the routine to see what hex number is going into the routine and see if the BCD number that came out is

Simple Program for Trace Demonstration

TRACE.ASM
15 FEBRUARY 1983
DO-WHILE JONES

; THIS IS USED TO DEMONSTRATE HOW TO TRACE THROUGH
; BDOS CALLS.
;
; GLOBAL ADDRESSES

0005 = BDOS EQU 0005H

0100 ORG 100H

0100 210000 LXI H,0 ; CLEAR THE H/L PAIR
0103 0E1F MVI C,31 ; GET ADDRESS OF DISK PARAMETERS
0105 CD0500 CALL BDOS ; USING BDOS COMMAND 31
0108 00 NOP ; DUMMY OP CODE
0109 C30901 SELF: JMP SELF ; DO FOREVER LOOP

010C END

Listing 1.

correct. Don't Trace through the whole routine *unless* the BCD answer is wrong. Then it makes sense to Trace to see why it gave the wrong answer. If you try to use "G" to execute a portion of a routine and never see the "*" prompt, it means the program has gone to "never-never land." Then you might want to Trace to see where you PUSHed without a POP in a subroutine, or where you selected the wrong condition for a conditional jump. But it is best to try to isolate the error using break points before using Trace.

Do-While's Rule:
Never Trace more than you have to.

DDT Saves You From Yourself

The good folks at Digital Research put a lot of thought into the DDT program. They foresaw users trying to Trace through a program which contains a BDOS call to output to the console (or worse yet, read a sector). They knew how

frustrated the user would be if the screen filled up with dozens of lines of BDOS code. On those rare occasions when I have resorted to Trace, and have happened to Trace through a BDOS command, I have been very grateful that DDT turned off the display until the BDOS function returned control to my own program.

Normally you should not care what the BDOS does internally. All you care about is that the return parameters are correct. You can find that out by putting a break point immediately after the BDOS call. Then you can examine registers (or memory) to see what it did, without having to try to figure out how it did it. Be sure to check the flag register. There are times when BDOS returns with the accumulator = 00, but the zero flag is *not* set. Since the JZ (Jump on Zero) instruction looks at the zero flag rather than the contents of the accumulator, your program may not branch to the desired routine unless you checked the zero flag with ANA A.

Is There Ever A Proper Time to Trace BDOS Calls?

There has only been one time that I ever found it necessary to Trace a BDOS function. I wrote an extension to CP/M 2.2 which allowed data to be displayed simultaneously on the console screen and stored in a disk file. In this case I tried to call some BDOS routines from BIOS, and the program crashed because the BDOS is not reentrant. I needed to find out why it was crashing and how to avoid it. I Traced through enough of BDOS to find out what prevented the subroutine from returning, and fortunately I was able to find other entry points which allowed me to use the BDOS subroutines to write a sector and close a file. Procedure 2 (page 62) shows the method I used.

The Trick – Two CP/M Systems at Once

After demonstrating the problem using Procedure 1, I went back to the sys-

Procedure 1.

48K VERSION 2.2 CP/M

```
A>DDT TRACE.HEX
DDT VERS 2.2
NEXT PC
010C 0000
-L100, 10B
 0100 LXI H, 0000
 0103 MVI C, 1F
 0105 CALL 0005
 0108 NOP
 0109 JMP 0109
 010C
-G100, 109
*0109
-X
C0Z1M0E1I0 A=7E B=B400 D=0000 H=B47E S=0100 P=0109 JMP 0109
-
-G100, 100
*0100
-T0C
C0Z1M0E1I0 A=7E B=B400 D=0000 H=B47E S=0100 P=0100 LXI H, 0000
C0Z1M0E1I0 A=7E B=B400 D=0000 H=0000 S=0100 P=0103 MVI C, 1F
C0Z1M0E1I0 A=7E B=B41F D=0000 H=0000 S=0100 P=0105 CALL 0005
C0Z1M0E1I0 A=7E B=B41F D=0000 H=0000 S=00FE P=0005 JMP 9500
C0Z1M0E1I0 A=7E B=B41F D=0000 H=0000 S=00FE P=9500 JMP 9BA2
C0Z1M0E1I0 A=7E B=B41F D=0000 H=0000 S=00FE P=9BA2 XTHL
C0Z1M0E1I0 A=7E B=B41F D=0000 H=0108 S=00FE P=9BA3 SHLD A44A
C0Z1M0E1I0 A=7E B=B41F D=0000 H=0108 S=00FE P=9BA6 XTHL
C0Z1M0E1I0 A=7E B=B41F D=0000 H=0000 S=00FE P=9BA7 JMP A506
C0Z1M0E1I0 A=7E B=B400 D=0000 H=B47E S=0100 P=0108 NOP
C0Z1M0E1I0 A=7E B=B400 D=0000 H=B47E S=0100 P=0109 JMP 0109
C0Z1M0E1I0 A=7E B=B400 D=0000 H=B47E S=0100 P=0109 JMP 0109+0109
-G0
```

tem and PIPed the TRACE.HEX file over to another disk, which had a different size CP/M system on it. I had an old disk with a 32K system on it that I had SYS-GENed when I only had 32K of memory in my system. So, without turning off the power, I cold-booted this 32K disk. This put a 32K CP/M system in memory, while leaving a copy of the 48K system there, too.

Procedure 2 gave results that were similar to Procedure 1, but they were not identical. The H/L pair returned the value 747E, which is exactly 16K lower than B47E because the 32K system is 16K smaller than the 48K system. Also, the JMP instruction at location 0005 sent the program to 5500 instead of 9500.

The BDOS routine at 9500 is still in memory but DDT doesn't know that. So look what happens if we change CALL 0005 to CALL 9500. We can reset the

program counter to the beginning of the test program with G100,100 and Trace a bunch of lines (36 hex is enough).

This time it's all there! After the JMP A506, the program counter goes to A506, rather than skipping down to 0108.

The group of instructions up to P=A546 PCHL is the BDOS entry routine which stores parameters, sets up the BDOS stack, and jumps to the selected BDOS routine. BDOS function 31 itself is only three lines.

```
LHLD B2BB
SHLD A845
RET
```

The nine lines after that are the BDOS exit routine, which restores parameters, restores the user stack, and fetches the answer from A845.

The desired Trace is shown in Procedure 3 on page 64.

Why It Works

Using a second CP/M system does two things that permit a successful Trace of BDOS functions:

- (1) DDT uses the 32K BDOS stack and 32K BDOS reserved memory locations while the test program is using the 48K BDOS stack and reserved memory locations.
- (2) DDT inhibits the display when the user program counter is in the 32K BDOS, but it doesn't care that the program counter is in the reserved area of the 48K BDOS. Therefore it permits the program flow to be displayed.

There's nothing really magical about 48K and 32K. You could use any two CP/M systems, providing they don't overlap. You probably have a 20K (or 24K)

A) PIP B:=TRACE.HEX

32K VERSION 2.2 CP/M

Procedure 2.

A) DDT TRACE.HEX

DDT VERS 2.2

NEXT PC

010C 0000

-L100, 10B

```
0100 LXI H, 0000
0103 MVI C, 1F
0105 CALL 0005
0108 NOP
0109 JMP 0109
010C
```

-G100, 109

*0109

-X

C0Z1M0E1I0 A=7E B=7400 D=0000 H=747E S=0100 P=0109 JMP 0109

-

-G100, 100

*0100

-T0C

C0Z1M0E1I0 A=7E B=7400 D=0000 H=747E S=0100 P=0100 LXI H, 0000

C0Z1M0E1I0 A=7E B=7400 D=0000 H=0000 S=0100 P=0103 MVI C, 1F

C0Z1M0E1I0 A=7E B=741F D=0000 H=0000 S=0100 P=0105 CALL 0005

C0Z1M0E1I0 A=7E B=741F D=0000 H=0000 S=00FE P=0005 JMP 5500

C0Z1M0E1I0 A=7E B=741F D=0000 H=0000 S=00FE P=5500 JMP 5BA2

C0Z1M0E1I0 A=7E B=741F D=0000 H=0000 S=00FE P=5BA2 XTHL

C0Z1M0E1I0 A=7E B=741F D=0000 H=0108 S=00FE P=5BA3 SHLD 644A

C0Z1M0E1I0 A=7E B=741F D=0000 H=0108 S=00FE P=5BA6 XTHL

C0Z1M0E1I0 A=7E B=741F D=0000 H=0000 S=00FE P=5BA7 JMP 650E

C0Z1M0E1I0 A=7E B=7400 D=0000 H=747E S=0100 P=0108 NOP

C0Z1M0E1I0 A=7E B=7400 D=0000 H=747E S=0100 P=0109 JMP 0109

C0Z1M0E1I0 A=7E B=7400 D=0000 H=747E S=0100 P=0109 JMP 0109*0109

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"distribution system" that you could use in conjunction with your full-size system.

It doesn't matter which you load first if there is sufficient space between the systems. But if the systems are nearly of equal size (like 24K and 32K), you might have trouble if you load the smaller one first. DDT moves itself to a position just below the CP/M system, so if it tries to put itself just below a 32K system, it might land on top of the 24K system. If you boot the bigger system first (as I did in the example) and then DDT from the smaller system, DDT will

be below the smaller system, so it can't interfere with the larger system.

They Said It Couldn't Be Done

The previous letters to Dr. Dobb said that it is impossible to Trace in the BDOS because it is not reentrant, so "attempts to trace through BDOS will result in the saved values being overwritten and destroyed by the recursive BDOS calls made by the debugger. This tends to send you to a tight loop in never-ever land."

This is true. But just because something is impossible doesn't mean that it can't be done. Every good stage magician knows that. If you can create the illusion that it is being done, that is good enough.

DDJ

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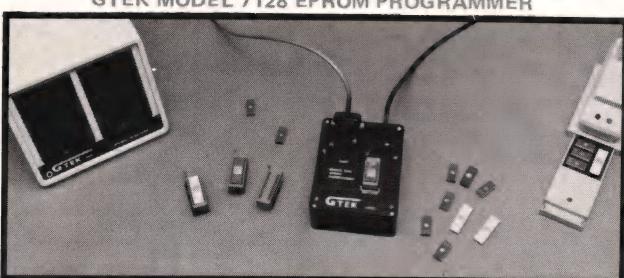
-S10E
0106 05 00
0107 00 95
0108 00 .
-L100, 10B
0100 LXI H, 0000
0103 MVI C, 1F
0105 CALL 9500
0108 NOP
0109 JMP 0109
010C

-G100, 100
*0100
-T36
C0Z1M0E1I0 A=7E B=7400 D=0000 H=747E S=0100 P=0100 LXI H, 0000
C0Z1M0E1I0 A=7E B=7400 D=0000 H=0000 S=0100 P=0103 MVI C, 1F
C0Z1M0E1I0 A=7E B=741F D=0000 H=0000 S=0100 P=0105 CALL 9500
C0Z1M0E1I0 A=7E B=741F D=0000 H=0000 S=00FE P=9500 JMP 9BA2
C0Z1M0E1I0 A=7E B=741F D=0000 H=0000 S=00FE P=9BA2 XTHL
C0Z1M0E1I0 A=7E B=741F D=0000 H=0108 S=00FE P=9BA3 SHLD A44A
C0Z1M0E1I0 A=7E B=741F D=0000 H=0108 S=00FE P=9BA6 XTHL
C0Z1M0E1I0 A=7E B=741F D=0000 H=0000 S=00FE P=9BA7 JMP A506
C0Z1M0E1I0 A=7E B=741F D=0000 H=0000 S=00FE P=A506 JMP A511
C0Z1M0E1I0 A=7E B=741F D=0000 H=0000 S=00FE P=A511 XCHG
C0Z1M0E1I0 A=7E B=741F D=0000 H=0000 S=00FE P=A512 SHLD A843
C0Z1M0E1I0 A=7E B=741F D=0000 H=0000 S=00FE P=A515 XCHG
C0Z1M0E1I0 A=7E B=741F D=0000 H=0000 S=00FE P=A516 MOV A, E
C0Z1M0E1I0 A=00 B=741F D=0000 H=0000 S=00FE P=A517 STA B2D6
C0Z1M0E1I0 A=00 B=741F D=0000 H=0000 S=00FE P=A51A LXI H, 0000
C0Z1M0E1I0 A=00 B=741F D=0000 H=0000 S=00FE P=A51D SHLD A845
C0Z1M0E1I0 A=00 B=741F D=0000 H=0000 S=00FE P=A520 DAD SP
C0Z1M0E1I0 A=00 B=741F D=0000 H=00FE S=00FE P=A521 SHLD A80F
C0Z1M0E1I0 A=00 B=741F D=0000 H=00FE S=00FE P=A524 LXI SP, BE00
C0Z1M0E1I0 A=00 B=741F D=0000 H=00FE S=BE00 P=A527 XRA A
C0Z1M0E1I0 A=00 B=741F D=0000 H=00FE S=BE00 P=A528 STA B2E0
C0Z1M0E1I0 A=00 B=741F D=0000 H=00FE S=BE00 P=A52B STA B2DE
C0Z1M0E1I0 A=00 B=741F D=0000 H=00FE S=BE00 P=A52E LXI H, B274
C0Z1M0E1I0 A=00 B=741F D=0000 H=B274 S=BE00 P=A531 PUSH H
C0Z1M0E1I0 A=00 B=741F D=0000 H=B274 S=BDFE P=A532 MOV A, C
C0Z1M0E1I0 A=1F B=741F D=0000 H=B274 S=BDFE P=A533 CPI 29
C1Z0M1E0I0 A=1F B=741F D=0000 H=B274 S=BDFE P=A535 RNC
C1Z0M1E0I0 A=1F B=741F D=0000 H=B274 S=BDFE P=A536 MOV C, E
C1Z0M1E0I0 A=1F B=7400 D=0000 H=B274 S=BDFE P=A537 LXI H, A547

(Continued on top of page 65)

C1Z0M1E0I0 A=1F B=7400 D=0000 H=A547 S=BDFE P=A53A MOV E, A
 C1Z0M1E0I0 A=1F B=7400 D=001F H=A547 S=BDFE P=A53B MVI D, 00
 C1Z0M1E0I0 A=1F B=7400 D=001F H=A547 S=BDFE P=A53D DAD D
 C0Z0M1E0I0 A=1F B=7400 D=001F H=A566 S=BDFE P=A53E DAD D
 C0Z0M1E0I0 A=1F B=7400 D=001F H=A585 S=BDFE P=A53F MOV E, M
 C0Z0M1E0I0 A=1F B=7400 D=0026 H=A585 S=BDFE P=A540 INX H
 C0Z0M1E0I0 A=1F B=7400 D=0026 H=A586 S=BDFE P=A541 MOV D, M
 C0Z0M1E0I0 A=1F B=7400 D=B226 H=A586 S=BDFE P=A542 LHLD A843
 C0Z0M1E0I0 A=1F B=7400 D=B226 H=0000 S=BDFE P=A545 XCHG
 C0Z0M1E0I0 A=1F B=7400 D=0000 H=B226 S=BDFE P=A546 PCHL
 C0Z0M1E0I0 A=1F B=7400 D=0000 H=B226 S=BDFE P=B226 LHLD B2BB
 C0Z0M1E0I0 A=1F B=7400 D=0000 H=B47E S=BDFE P=B229 SHLD A845
 C0Z0M1E0I0 A=1F B=7400 D=0000 H=B47E S=BDFE P=B22C RET
 C0Z0M1E0I0 A=1F B=7400 D=0000 H=B47E S=BE00 P=B274 LDA B2DE
 C0Z0M1E0I0 A=00 B=7400 D=0000 H=B47E S=BE00 P=B277 ORA A
 C0Z1M0E1I0 A=00 B=7400 D=0000 H=B47E S=BE00 P=B278 JZ B291
 C0Z1M0E1I0 A=00 B=7400 D=0000 H=B47E S=BE00 P=B291 LHLD A80F
 C0Z1M0E1I0 A=00 B=7400 D=0000 H=00FE S=BE00 P=B294 SPHL
 C0Z1M0E1I0 A=00 B=7400 D=0000 H=00FE S=00FE P=B295 LHLD A845
 C0Z1M0E1I0 A=00 B=7400 D=0000 H=B47E S=00FE P=B298 MOV A, L
 C0Z1M0E1I0 A=7E B=7400 D=0000 H=B47E S=00FE P=B299 MOV B, H
 C0Z1M0E1I0 A=7E B=B400 D=0000 H=B47E S=00FE P=B29A RET
 C0Z1M0E1I0 A=7E B=B400 D=0000 H=B47E S=0100 P=0108 NOP
 C0Z1M0E1I0 A=7E B=B400 D=0000 H=B47E S=0100 P=0109 JMP 0109
 C0Z1M0E1I0 A=7E B=B400 D=0000 H=B47E S=0100 P=0109 JMP 0109*0109
 -GO

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Julian Dates for Microcomputers

Julian dates have long been used by astronomers to facilitate accurate reckoning of dates over long periods of time, and they can also be extremely useful in various applications of computers. A Julian date is simply the number of a given day counted in sequence from some base date which is assigned Julian date 0. For example, if 1 January 1983 is taken as the base date 0, then 2 January 1983 would have Julian date 1, 3 January 1983 would have Julian date 2, and 1 January 1984 would have Julian date 365.

There are at least four reasons why Julian dates can be usefully applied in computer programs (inventive comput-erists can probably find more):

(1) The Julian date provides a compact and economical way of storing a date as opposed to representing it as a string of ASCII characters.

(2) Any two dates may be simply compared by an arithmetic test to determine which date is earlier. This is especially useful when items are to be sorted by date.

(3) The exact number of days between any two dates can be determined by a simple subtraction.

(4) When a Julian date is divided by 7, the remainder gives the corresponding day of the week (this will be explained in more detail below).

True Julian dates as used by astronomers take noon, 1 January 4713 B.C. as the base date (astronomers count days from noon to noon). But for most computer work, it's more useful to take a year someplace in the current century as a base year, because there normally is no need to reference dates very far back in the past. A base date in 1900, for example, would be sufficient for the Julian date representation of employee birth dates in almost any business today. Furthermore, restricting the forward span of dates from the base date to some reasonable future limit allows the Julian date to be stored and manipulated economically. For example, choosing to store a Julian date in a 16-bit word (two bytes) allows a span of 65,536 days, which is approximately 179.4 years. The algorithms for Julian

date conversion given below, which use a 16-bit Julian date, allow a base year to be chosen between 1900 and 1920, thus giving a terminating date between 2079 and 2099 in the next century.

In order to use Julian dates on a computer, two conversion routines are needed: CTOJ, which converts a calendar date to a Julian date, and JTOC, which converts a Julian date back to a calendar date. The routines given here are based on Algorithm 199 in *The Collected Algorithms of the ACM*, as presented by R. G. Tantzen in 1963. Calendar dates are given in the form DAY (an integer from 1 to 31), MONTH (an integer from 1 to 12), and YEAR (an integer from 1900 to 2099). The Julian date is given (or returned) as the 16-bit unsigned integer JDATE, ranging from 0 (Julian date 0) to 65,535 (last day).

The base date is 1 March 1900, or 1 March of any leap year after 1900 not greater than 1920. The first of March rather than the first of January is used as a base date in order to avoid problems with 29 February in leap years. For similar reasons, the routines as given will not work for dates before 1900 or after 2099 (1900 and 2100 are not leap years, while 2000 is). Readers interested in representing dates outside these ranges should refer

to Tantzen's original algorithms, which handle any Gregorian calendar date (but not within 16 bits).

The conversion routines are shown first in a pseudo higher-level language to make the algorithms clear (see Figure 1, below). But the reader should be cautioned that they cannot be directly translated into any higher-level language which, like many BASICs, doesn't support long (32-bit) integer arithmetic. Though the results are all 16-bit quantities (or less), some of the intermediate calculation requires 32-bit arithmetic, and the algorithms also depend on the properties of integer division.

As illustrated in Figure 1, the normal month number is converted to the number of a month in a pseudo year running from 1 March through 28 (or 29) February, and the year number is adjusted if necessary. The magic number 1461 which appears in CTOJ is simply the number of days in a leap-year cycle of three years of 365 days each and one year of 366 days. Therefore the expression $(1461 * y)/4$ gives the total number of days in all preceding years from the base year up to the specified year. The integer function $(153 * m + 2)/5$ similarly gives the total number of days in any pseudo year up to, but not including, month m. Therefore, adding DAY to the sum of the

Conversion of Calendar Date to Julian Date

```
CTOJ:   y = YEAR - Base Year
        If MONTH .gt. 2, m = MONTH - 3
              else m = MONTH + 9, y = y - 1
        JDATE = (1461*y)/4 + (153*m + 2)/5 + DAY - 1
```

Conversion of Julian Date to Calendar Date

```
JTOC:   y = (4*JDATE + 3)/1461
        d = (4*JDATE + 3) mod 1461
        YEAR = y + Base Year
        d = d/4 + 1
        m = (5*d - 3)/153
        d = (5 * d - 3) mod 153
        DAY = d/5 + 1
        If m .lt. 10, MONTH = m + 3
              else MONTH = m - 9, YEAR = YEAR + 1
```

Figure 1.

by Gordon King

Gordon King, King Software, P.O. Box 208, Red Bank, New Jersey 07701.

two preceding expressions gives the day number of the specified calendar date; and finally subtracting 1 gives the base-zero Julian date. The routine JTOC simply reverses the above calculation to convert back to calendar date.

The JDATE numbers used by these algorithms may also be converted to day numbers in other similar date systems by the addition or subtraction of a suitable conversion constant. Suppose that FDATE is such a day number in some "foreign" date system which also numbers days sequentially, but from a different base date. Then

$$\text{JDATE} = \text{FDATE} + \text{CC}$$

and

$$\text{FDATE} = \text{JDATE} - \text{CC}$$

where CC is the conversion constant, which is simply the JDATE value for the base date of the foreign system; it must of course lie within the valid JDATE range. For example, MP/M and CP/M Plus use a 16-bit integer date with 1 January 1978 taken as Day 1 (hence 31 December 1977 is Day 0). The JDATE value for 31 December 1977 is 28,429 if 1900 is used as the JDATE base year, or 21,124 for base year 1920. Therefore simply adding the appropriate one of these two constants to MP/M's date at the beginning of the routine JTOC converts it to the corresponding JDATE and results in the correct calendar date. Conversely, subtracting it from JDATE at the end of the routine CTOJ gives back the MP/M-form date corresponding to the given calendar date (calendar dates before 31 December 1977 will result in negative MP/M dates, which may have some useful interpretation outside of MP/M itself).

Before going on to present the two routines in Z80 assembly language, mention should be made of the method of determining the day of the week corresponding to a given Julian date. When a Julian date is divided by 7, the remainder will be one of the seven numbers from 0 to 6 (the quotient is ignored). These correspond to the seven days of the week in order, beginning from a day which depends on the base year. For base year 1900, a remainder of 0 means Thursday, 1 means Friday, and so on down to 6, which means Wednesday. For base year 1920, a remainder of 0 means Monday, 1 means Tuesday, etc. Consequently, these remainders can be used to index into a suitably ordered table of day names when it's required to print the day of the week corresponding to a given date (after it's been converted to a Julian date, of course).

Finally, the listing (page 68) provides the two conversion subroutines in Z80 assembly language. The date is transferred in the byte DAY, the byte MONTH, and

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the word (two bytes) YEAR, while the Julian date is transferred in the word JDATE. Since the Julian date is contained in a 16-bit word, the legal range of dates is from 1 March 1900 to 4 August 2079 if 1900 is chosen as the base year, or from 1 March 1920 to 4 August 2099 if 1920 is chosen as the base.

The subroutine CTOJ checks DAY, MONTH, and YEAR for legal values and jumps to a routine ERROR (not supplied) in case they're out of range. Two subroutines are also supplied for integer multiplication and division, but if date conversions are to be done heavily, as in an inner loop, some improvement in per-

formance could be gained by using shifts and/or adds to do the multiplications by 4 and 5 and the divisions by 4. **DBJ**

(Listing begins below)

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Julian Dates (Text begins on page 66)

```

YEAR0      = 1900          ;BASE YEAR
;CONVERT CALENDAR DATE TO JULIAN

CTOJ: LD    HL,(YEAR)      ;GET THE YEAR
      LD    A,(MONTH)     ;AND THE MONTH
      OR    A,A           ;CHECK FOR A LEGAL VALUE
      JP    Z,ERROR
      CP    A,12+1
      JP    NC,ERROR
      SUB   A,3            ;MONTH IN MAR-FEB "YEAR"
      JR    NC,CTOJ1
      ADD   A,12           ;JAN OR FEB BECOME 10, 11
      DEC   HL              ;OF PREVIOUS YEAR
CTOJ1: LD    E,A           ;PUT MONTH IN DE
      LD    D,0
      LD    BC,-YEAR0       ;SUBTRACT THE BASE YEAR
      ADD   HL,BC
      LD    A,H             ;CHECK FOR LEGAL YEAR
      OR    A,A
      JP    NZ,ERROR
      LD    A,L
      CP    A,179+1
      JP    NC,ERROR
      PUSH  DE              ;SAVE THE MONTH
      LD    DE,1461          ;DAYS IN A LEAP-YEAR CYCLE
      CALL  MULWW           ;DE*HL TO (DE,HL)
      LD    BC,4
      CALL  DIVLW           ;(DE,HL)/BC TO DE (QUOTIENT)
      POP   HL              ;GET THE MONTH BACK
      PUSH  DE              ;SAVE (YEAR*1461)/4
      LD    DE,153            ;DE*HL TO (DE,HL)
      CALL  MULWW
      INC   HL              ;ADD 2
      INC   HL              ;(NO OVERFLOW POSSIBLE)
      LD    BC,5
      CALL  DIVLW           ;(DE,HL)/BC TO DE (QUOTIENT)
      POP   HL              ;GET BACK FIRST TERM
      ADD   HL,DE            ;ADD (153*MONTH + 2)/5
      JP    C,ERROR          ;ERROR IF OVERFLOW
      LD    A,(DAY)          ;GET DAY
      DEC   A                ;REDUCE BY ONE FOR BASE-0 J.D.
      CP    A,31              ;CHECK FOR LEGAL VALUE

```

```

JP      NC, ERROR
LD      E, A           ; TO DE
LD      D, 0
ADD    HL, DE          ; ADD IN
JP      C, ERROR        ; ERROR IF OVERFLOW
LD      (JDATE), HL     ; STORE AWAY
RET

```

; CONVERT JULIAN DATE BACK TO CALENDAR DATE

```

JTOC:   LD      HL, (JDATE)      ; GET THE JULIAN DATE
        LD      DE, 4           ; 4*JDATE + 3
        CALL   MULWW          ; DE*HL TO (DE,HL)
        LD      BC, 3
        ADD    HL, BC
        JR      NC, JTOC1
        INC    DE
JTOC1:  LD      BC, 1461         ; y = (4*JDATE + 3)/1461
        CALL   DIVLW          ; (DE,HL)/BC TO DE(Q) AND HL(R)
        PUSH   DE             ; SAVE y, HL HAS d (REMAINDER)
        LD      BC, 4           ; d = d/4 + 1
        LD      DE, 0
        CALL   DIVLW          ; (DE,HL)/BC TO DE(Q)
        INC    DE
        LD      HL, 5           ; 5*d - 3
        CALL   MULWW          ; DE*HL TO (DE,HL)
        LD      BC, 3
        OR     A, A
        SBC   HL, BC
        JR      NC, JTOC2
        DEC    DE
JTOC2:  LD      BC, 153          ; m = (5*d - 3)/153
        CALL   DIVLW          ; (DE,HL)/BC TO DE(Q) AND HL(R)
        PUSH   DE             ; SAVE m, HL HAS d (REMAINDER)
        LD      BC, 5           ; DAY = d/5 + 1
        LD      DE, 0
        CALL   DIVLW          ; (DE,HL)/BC TO DE(Q)
        INC    DE
        LD      A, E
        LD      (DAY), A
        POP    HL             ; m
        POP    DE             ; y
        LD      A, L           ; MONTH = m + 3
        ADD    A, 3
        CP     A, 12+1         ; IF MONTH .GT. 12,
        JR      C, JTOC3
        SUB    A, 12
        INC    DE             ; MONTH = MONTH - 12
        LD      (MONTH), A     ; y = y + 1
        LD      HL, YEAR0       ; YEAR = y + Base Year
        ADD    HL, DE
        LD      (YEAR), HL
        RET

```

(Continued on next page)

Julian Dates (Listing continued, text begins on page 66)

;MULTIPLY HL*DE, RETURN 32-BIT PRODUCT IN DE (HIGH) AND HL (LOW)

```
MULWW: LD B,H ;MULTIPLICAND TO BC
       LD C,L
       LD HL,0 ;INITIALIZE PRODUCT
       LD A,16 ;COUNT 16-BIT MULTIPLIER
MULWW1: ADD HL,HL ;SHIFT DE,HL LEFT ONE
       EX DE,HL
       ADC HL,HL
       EX DE,HL
       JR NC,MULWW2 ;JUMP IF NO MULTIPLIER BIT
       ADD HL,BC ;ELSE ADD MULTIPLICAND TO RESULT
       JR NC,MULWW2 ;IF LOW ORDER WORD OVERFLOWS,
       INC DE ; CARRY INTO HIGH ORDER
MULWW2: DEC A ;CONTINUE FOR 16 BITS
       JR NZ,MULWW1
       RET
```

;DIVIDE (DE,HL) BY BC. QUOTIENT TO DE, REMAINDER TO HL.

```
DIVLW: EX DE,HL ;HIGH ORDER TO HL, LOW TO DE
       LD A,16 ;COUNT 16-BIT QUOTIENT
DIVLW1: EX DE,HL ;SHIFT ONE BIT FROM DE TO HL
       ADD HL,HL
       EX DE,HL
       ADC HL,HL
       SBC HL,BC ;WILL DIVISOR GO IN YET?
       JR NC,DIVLW3
       ADD HL,BC ;NO - RESTORE HL
       DIVLW2: DEC A ;CONTINUE FOR 16 BITS
       JR NZ,DIVLW1
       RET
       DIVLW3: INC DE ;INCREMENT QUOTIENT
       JR DIVLW2 ;LEAVE RESIDUE IN HL, CONTINUE
```

End Listing

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16-BIT SOFTWARE TOOLBOX

by Ray Duncan

8088 Addressing Modes

The short comment on 8088 Base Relative Indexed Stack addressing and the table from Leo Scanlon's book, printed in this column a few months ago, drew a surprising number of letters. Albert Brunelli, of N. Chelmsford, Mass., practically wrote a whole tutorial; I found it so helpful that I am reprinting it verbatim below.

"I am writing in response to the 16-Bit Software Toolbox column of March 1983. The primary purpose of this letter is to explain some of the uses of the 8086/88's BP register. First I will comment on Leo Scanlon's listing on page 17 of the March 1983 issue.

"The subroutine will prove only that the DS register is not the default segment for BP-based memory references. The ASSUME statement does not change any register. It is merely a means of assuring the assembler that you know what you are doing when you make an anonymous reference (use a base or index as an offset without specifying a segment register). Mr. Scanlon appears to understand this when he initializes the DS register. However, he never initializes the SS register to the segment STACK which he would have to do to prove his case. If he were to change the SS to STACK, and if it weren't already pointing at STACK of course, he could never return from the subroutine. If the DL and DH registers hold OFFh at the end of the routine, it is merely a coincidence. He would do better to push the data onto the stack and then retrieve it using the BP register. This technique will become clearer as we get further along.

"To get a good feel for the intended use of the BP register, one must understand the philosophy behind the use of the 8086 instruction set. As I understand it, Intel wanted to create a microprocessor with an instruction set which lent itself well to the implementation of high-level languages, specifically to Intel's systems language, PL/M.

"In PL/M and most other structured languages, most arguments are passed to procedures (functions, subroutines) on the stack. However, since the return address will be the lowest address on the stack, considerable manipulation must be done to access the arguments while maintaining the return address. Intel added two nice features to the instruction set to make argument retrieval easier. The BP register is one of these.

"Let's assume we wish to pass two

arguments to the FAR subroutine SUB1. low address OLD AX ;"top" of stack
We might pass them as shown below:

```
PUSH CX  
PUSH DX  
CALL SUB1
```

"After the CALL instruction is executed, the stack will look like this:

low address	OLD IP	offset
	OLD CS	segment
	ARG2	from DX
high address	ARG1	from CX

"To retrieve the arguments and return properly, SUB1 might follow the procedure:

```
SUB1 PROC FAR  
PUSH BP  
MOV BP,SP  
PUSH DS ;save registers  
PUSH SI  
PUSH AX  
..... ;body of subroutine  
.....  
DONE: POP AX  
POP SI  
POP DS  
POP BP  
RET 4  
SUB1 ENDP
```

"Moving SP to BP will allow us to index into the arguments passed on the stack using BP. The contents of the stack when we get to the body of SUB1 are shown as follows:

low address	OLD AX	;top" of stack
	OLD SI	
	OLD DS	
	OLD BP	;BP points here
	OLD IP	;BP+2
	OLD CS	;BP+4
	ARG2	;BP+6
high address	ARG1	;BP+8

"We may thus retrieve the arguments with the instructions:

```
MOV AX,[BP+6]  
;fetch ARG2  
MOV SI,[BP+8]  
;fetch ARG1
```

"Any reference using BP as a base will assume that it is in reference to the stack segment (with or without an ASSUME declaration).

"Now we have fetched the arguments without disturbing the return address. How will we clean up the stack so that the arguments will not clutter it up forever? Once again Intel comes to the rescue with the 'RET n' instruction. The 'n' part of the instruction tells the processor how many bytes to discard from the stack after it has taken off the return address. In other words, it will add 'n' to the stack pointer (SP) after fetching the return address.

"The final use to which I will put the BP register is one which I have found very helpful in memory-test programs which do not have access to the, as yet unverified, stack area of RAM. We may create synthetic subroutines which may be

LEA	BX, TABLE_1	;point to ROM table
MOV	CX, NUM_ENTRIES	;number of table entries
LEA	BP, CONT1	;BP becomes return addr
JMP	SYN_SUB1	
CONT1:	;control returns here
	
SYN_SUB1:		;synthetic subroutine
	
	
JMP	BP	;pseudo-return instr.

Figure 1.

'called' from anywhere within the same code segment. The idea is that the return address is placed in a register before jumping to the subroutine, which terminates with a jump register instruction such as shown in Figure 1, page 72.

"The LEA BP instruction will place the offset of the CONT1 label in the BP register. The BP register is the perfect one to use in a situation like this because we have no stack to which it may point. The JMP BP instruction may be thought of as roughly equivalent to the 8080's PCHL instruction, although it is more powerful since any general register may be used as the source."

Wishful Thinking Dept.

Jim Howell wrote to point out a truly glaring error, found on page 3-13 of the *iAPX-88 Book* (July 1981 edition), which readers of this column may find amusing or amazing. "16-bit operands are stored in memory with the most significant byte (MSB) first, followed by the least significant byte (LSB) in the next location." The picture set at the bottom of the page in the book repeats this error.

8088 Line Generator

Dan Rollins of Glendale, Calif. sent in an 8088 assembler version of the fast-vector algorithm featured in Dave Cortesi's column of December 1982 and February 1983. His comments follow:

"The routine is self-modifying and needs no external storage area. The code that calculates the coordinate pairs is blazing fast. It's a shame that the BIOS write-dot routine (which it calls) is so slow. I am using a version of this routine in an arcade game I am currently writing. All of the drawing and point testing in that game takes place in a buffer and I use a much faster PLOTDOT routine."

Listing 1 (page 75) contains the line generation subroutine proper, while Listing 2 (page 77) demonstrates how to call the subroutine from BASIC.

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(Listings begin on page 75)

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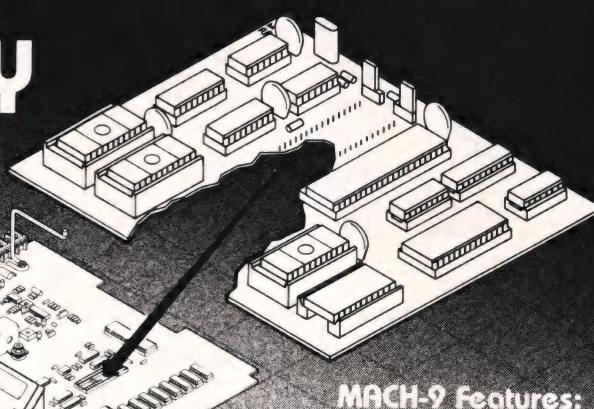
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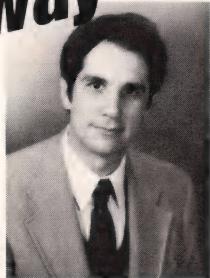


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logarithm	390	2.6	N.A.
square root	500	1.7	2.3

¹ Iterative loop on CompuPro/Hudson CP/M system (8085 @ 6MHz and 8088/87 @ 5MHz).

² FORTH with 8087 64-bit floating point on IBM P.C., Dr. Dobb's J., Nov. 1982, p. 46.

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The Line Generator Subroutine

Listing One (Text begins on page 72)

```
Page 132
title DRAWLINE.ASM      Dan Rollins

        Public drawline

;8088 self-modifying program implements fast-vector algorithm
; described by Michalsky, DDJ #74, 12/82
; see also: FAST-LINE DRAWING TECHNIQUE, BYTE, Aug 81

;routine expects to be called from BASIC via:
;        CALL DRAWLINE(VZ(0))

; where VZ(0) = X1    starting col (0-319)
;       VZ(1) = Y1    starting row (0-159)
;       VZ(2) = X2    ending col
;       VZ(3) = Y2    ending row
;       VZ(4) = color (0,1,2,3)
;       VZ(5) = length
;           0 = draw entire line
;           else = draw sub- or super-set of this vector

0000      code     group   cses
          cses    segment public 'code'
          assume CS:cses, DS:nothing, ES:nothing

; make it easier to access variables and arguments
ARG1      equ      word ptr [BP+6]

;=
; X1      equ      word ptr [si]
; Y1      equ      word ptr [si+2]
; X2      equ      word ptr [si+4]
; Y2      equ      word ptr [si+6]
; COLOR   equ      byte ptr [si+8]
; LEN     equ      word ptr [si+10]

; these are values that will be inserted in the code
= 0041    INC_X   equ      41H
= 0049    DEC_X   equ      49H
= 0042    INC_Y   equ      42H
= 004A    DEC_Y   equ      4AH

; these are the addresses where new code is overlayed
ADJ_LONG_AXIS  equ      byte ptr cs:[di]
ADJ_MASTER     equ      word ptr cs:[di+3]
TEST_MASTER    equ      word ptr cs:[di+7]
ALT_ADJ_MASTER equ      word ptr cs:[di+13]
ADJ_SHRT_AXIS  equ      byte ptr cs:[di+15]

;=
; Page
0000      drawline proc far
          push    bp      ;always save
          mov     bp,sp
          mov     si,ARG1  ;si => address of X1 ;ie, VZ(0)

0003 8B 76 06
```

(Continued on next page)

The Line Generator Subroutine

Listing One (Listing continued, text begins on page 72)

```
0006 B3 41          mov     bl,INC_X ;assume Xstep = +1
0008 BB 44 04        mov     ax,X2
000B 2B 04          sub     ax,X1
000D 7D 04          jse     dl1      ;if X1 <= X2 then no change
000F B3 49          mov     bl,DEC_X ;Xstep = -1
0011 F7 D8          nes     ax      ;Xdist = abs(Xdist)
0013               dl1:    mov     cx,ax      ;save Xdist
0013 8B C8
0015 B7 42          mov     bh,INC_Y ;assume Ystep = +1
0017 BB 44 06        mov     ax,Y2
001A 2B 44 02        sub     ax,Y1
001D 7D 04          jse     dl2      ;if Y1 <= Y2 then no change
001F B7 4A          mov     bh,DEC_Y ;Ystep = -1
0021 F7 D8          nes     ax      ;Ydist = abs(Ydist)
0023               dl2:    mov     dx,ax      ;save Ydist
0023 8B D0          mov     di,[offset cs:modify_base] ;point to the code
0025 BF 005D R       ;to modify
0028 3B D1          cmp     dx,cx      ;determine longest axis
002A 7D 04          jse     dl3      ;Y is longer, so skip
002C 87 CA          xchs   cx,dx      ;swap Xdist, Ydist
002E 86 DF          xchs   bl,bh      ;swap INC/DEC X/Y values
0030               dl3:    mov     ah,ADJ_LONG_AXIS,bh ;the 1st INC/DEC code
0030 2E: 88 3D        mov     ah,ADJ_MASTER,cx ;main duty master adjustment
0033 2E: 89 4D 03        shr     cx,1      ;set up cycle tester
0037 D1 E9          mov     ah,TEST_MASTER,cx ;test for cycling
0039 2E: 89 4D 07        mov     ah,ALT_ADJ_MASTER,dx ;alternate adjustment
003D 2E: 89 55 0D        mov     ah,ADJ_SHRT_AXIS,bl ;alternate INC/DEC code
0041 2E: 88 5D 0F
0045 BB FA          mov     di,dx      ;DI is counter: long axis length
0047 83 7C 0A 00        cmp     di,LEN      ;if length arg > 0
004B 7E 03          jle     dl4      ;then use it as counter
004D 8B 7C 0A
0050               dl4:    mov     cx,X1
0050 8B 0C          mov     dx,Y1
0052 8B 54 02        mov     al,COLOR
0055 8A 44 08        xor     bx,bx      ;duty master starts = 0
0058 33 DB          page   ;----- top of vector plotting loop -----
005A               dl5:    call    PlotDot    ;plot a dot
005A E8 0074 R
005D               modify_base label  byte
005D 41          inc     cx      ;INC/DEC CX/DX: adjust long axis ptr
005E 81 C3 1111        add     bx,1111H ;Xdist or Ydist: adjust duty master
0062 81 FB 1111        cmp     bx,1111H ;Ydist or Xdist: check cycle position
0066 7E 05          jle     dl6      ;skip if short axis is still ok
```

```

0068 81 EB 1111          sub    bx,1111H ;Xdist or Ydist: adjust duty master
006C 42                  inc    dx      ;INC/DEC DX/CX: adjust short axis ptr
006D
006D 4F                  dec    di      ;di is used as counter
006E 7D EA                jse    d15    ;do next dot if not finished
                                ;
0070 5B
0071 CA 0002          pop    bp      ;always restore
0074                         ret    2       ;back to BASIC, discard 1 arg <<EXIT<<
                                drawline endp

                                ;this routine plots the pixel at column CX (0-319 or (0-639)
                                ;                                row     BX (0-199)
                                ;                                color   AL (0-3) or (0-1)
0074 50                  Plotdot Proc  near
0075 57                  push   ax
                                push   di      ;BIOS destroys these registers
0076 B4 0C          mov    ah,12      ;write_dot function
0078 CD 10          int    10H      ; video I/O call

007A 5F                  pop    di
007B 58                  pop    ax
007C C3                  ret
007D                         Plotdot endp

007D                         cseg    ends

```

End Listing One

Listing Two

```
' TESTER.BAS           Dan Rollins 02/02/83
' this compiled BASIC program tests the 8088-code DRAWLINE routine

defint a-z
dim vX(5)
screen 1
10:
  input"routine (1 or 2)":r
  if r=2 then 100

20:
  input"color (0-3, -1 to quit)":vX(4)
  if vX(4) < 0 then 30

  input"x1,y1,x2,y2":vX(0),vX(1),vX(2),vX(3)

  vX(5)=0
  input"length (null = full line)":vX(5)

  call drawline(vX(0))

soto 20

30:
  screen 0,0,0,0 :width 80 :end
```

(Continued on next page)

Calling the Subroutine from BASIC

Listing Two (Listing continued, text begins on page 72)

```
' LASER BEAMS: sample use of the length parameter

100:
    cls
    vX(0)=159 :vX(1)=(199)      'X1,Y1 = bottom center of screen
110:
    vX(2)=int(rnd*312)          'X2      = random column
    vX(3)=0                      'Y2      = top of screen

    vX(4)=3                      'color = white
    for length=10 to 190 step 10
        vX(5)=length             'set length
        call drawline(vX(0))     'draw partial line
    next
    vX(4)=0                      'color = black to erase
    for length=10 to 190 step 10
        vX(5)=length             'set length
        call drawline(vX(0))
    next

if inkey$="" then 110 else 30 'any key to exit
```

End Listing Two

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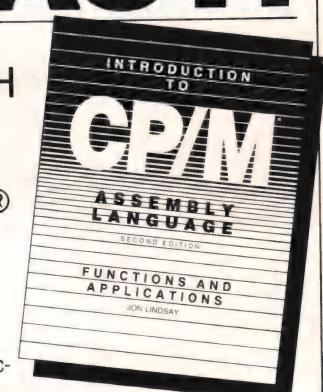
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by Robert Blum

Take a Look in the Public Domain...

Public domain software libraries continue to grow and the number of computerists involved in related activities is virtually exploding. The two predominate groups responsible for cataloging and distributing public domain software are the CP/M Users Group (CPMUG) and the Special Interest Group for Microcomputers (SIG/M). Collectively they offer over 140 volumes (almost 23 Mbytes) crammed full of programs. Many smaller groups specializing in specific programming languages and machines exist. Most have program libraries and are responsible for many of the software contributions of the larger groups.

CPMUG (1651 Third Avenue, New York, New York 10028) is the single largest distributor of CP/M public domain software, with 85 volumes in their library. No matter what your needs, from utilities to BASIC business software, it can be found in their catalog. At a nominal cost of \$12 per volume, a better bargain can't be found. Unfortunately, one stumbling block exists. With each new computer comes a new disk format and stocking all of them is beyond the resources of most groups. In response to this need, a few commercial concerns are now offering copies of the original disks in many of the more popular disk formats.

What is desperately needed is some universal form of machine-readable media. Since none are currently available, two alternate approaches can be used. The least costly is "paperware." Even though the cost is low, many hours will be spent keying in the program and then finding the transcription errors. The second approach requires the purchase of a modem. With a 300 baud modem you will have ready access to a number of Remote CP/M (RCPM) systems across the country. Many of them offer complete libraries of public domain software in addition to an amazing number of other useful programs.

One often-overlooked point is the educational value of public domain software. Many fine books and reference documents are available to provide the prerequisite training on the computers instruction set and the CP/M interface. But none can rival the first-hand experience of stepping through a working program with a debugger. As if by magic, the mysteries are solved as you watch each instruction execute.

If a list of the foremost activists in public domain software were made, Ward Christensen would rank in the top ten. His involvement with microcomputers began with their inception. As librarian of CPMUG, he exemplifies dedication to the public domain scene. To ease the log jam of phone calls to his RCPM system he has added a second phone line as an "administrative" and general CP/M message system (messages deal with bug fixes, reviewing and cataloging of CPMUG disks, etc.). Use 312-849-1132 (and the new "M" command and "CPMUG" password) to download the current CPMUG catalog of programs (not the individual files), retrieve a copy of the user group contribution form, send in a contribution, etc. The original CBBS in Chicago is at 312-545-8086, which supports baud rates of 110-600. Press return several times for speed detect. When using these numbers, be patient — they get a lot of activity.

Periodically, I will be reviewing programs from the public domain that provide topical information. For the edification of those who are interested, I will offer complete program listings along with the review at my cost of printing and shipping.

...at SD-44

Displaying the diskette directory is probably one of the most-used functions of CP/M. Unfortunately, the built-in command DIR produces an unsorted, single-column display which is hardly satisfactory when several hundred file names are to be scanned. CPMUG volume 85 contains SD-44, which I believe is the latest version in a series of full-feathered directory programs. The display produced is sorted, and three columns wide. Each file's size is given and the total space remaining on the diskette is calculated. This may sound like a description of many others but SD-44 offers a number of other features. The eight options recognized are:

S — system option: includes files in the output.

F — file option: echoes the directory output to a disk file on the default drive, named "SD.DIR." If SD.DIR already exists, then the directory output will be appended to the end of the file. Otherwise, SD.DIR will be created as a new file.

U — user option: allows the specification of the user number for the directory in the form "Un" where the user number, *n*, must be greater than 0 and no larger than 15. This option allows no spaces between "U" and *n*, and cannot be used on pre-CP/M 2.0 systems.

A — all users: displays directories of all user areas starting at the user area specified in the U option. If the U option is omitted, displays start with the default user area and continue up to MAXUSR.

R — reset option: provides automatic resetting of the disk prior to performing directory search, updating the allocation vector. Same as doing a Ctrl-C when changing disks, but handy if you didn't (such as when running a SUBMIT file). The RESFLG equate will force the R option unconditionally each time SD is run.

N — no page option: unconditionally disables the page pause option. SD will not put the page-pause prompt into the output file.

P — printer option: forces all console output to be echoed to the CP/M list device, with the most significant bit set to 0.

D — all disk option: allows SD to search all disk drives online starting with the disk drive specified or implied in the command line filename.

Outside of the obvious usefulness of SD-44, most of the techniques described in my series on BIOS internals can be found in this program. If you want a paperware copy of SD-44 and its documentation, send \$5.00 to the address at the end of this column.

More on CP/M Plus

The real story behind CP/M Plus's features unfolds when the BDOS functions are examined. Rather than include all the BDOS functions, Table I (page 82) only lists the additions and changes.

Many of the BDOS functions are now MP/M compatible. This fact makes me wonder what DR has in mind for future releases; possibly adding concurrent operation to CP/M or providing a natural upgrade path to MP/M. Whatever the

case, to make full use of all the new features will require some changes to the application program. Whether CP/M 2.2 programs will run without change under CP/M Plus is a question that can best be answered by running it. Providing trick code has been kept to a minimum, the success ratio should be high.

Next month I will continue with memory mapping and more on CP/M Plus's internals. You can reach me directly if you want to order paperware for SD-44, or to discuss subjects from this column, at: Bob Blum, 5536 Colbert Trail, Norcross, Georgia 30092; (404) 449-8948.

DDJ

(Table I begins on page 82)

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"Programming Language Translation" (Halstead Press) is "a major help to anyone interested in how Pascal works" (DDJ Sept., 1982).

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Table I.

CP/M Plus BDOS function addition and changes.

- 3 - *Auxiliary Input:* same as CP/M 2.2 reader input.
- 4 - *Auxiliary Output:* same as CP/M 2.2 punch output.
- 7 - *Auxiliary Input status:* new function call to test whether data is available at the auxiliary input device. Under CP/M 2.2 was *Get I/O Byte*.
- 8 - *Auxiliary Output status:* new function call to test whether data can be sent to the auxiliary device. Under CP/M 2.2 was *Set I/O Byte*.
- 38 - *Access Drive:* MP/M function call, provided for compatibility only.
- 39 - *Free Drive:* MP/M function call, provided for compatibility only.
- 41 - *Test and Write Record:* MP/M function call, provided for compatibility only.
- 42 - *Lock Record:* MP/M function call, provided for compatibility only.
- 43 - *Unlock Record:* MP/M function call, provided for compatibility only.
- 44 - *Set Multi-Sector Count:* allows from 1 to 128 128-byte sectors to be read or written in one operation. MP/M compatible.
- 45 - *Set BDOS Error Mode:* determines how errors are handled. MP/M compatible.
- 46 - *Get Disk Free Space:* determines how many free 128-byte sectors there are on the specified drive. MP/M compatible.
- 47 - *Chain to Program:* allows automatic chaining from one program to another. MP/M compatible.
- 48 - *Flush Buffers:* forces any remaining records marked for writing to be written. MP/M compatible.
- 49 - *Get/Set System Control Block:* allows the system control block to be changed.
- 50 - *Direct BIOS Calls:* allows direct BIOS calls to be made through BDOS functions. CP/M Plus no longer supports direct BIOS calls.
- 59 - *Load Overlay:* load a Resident System Extension (RSX) or overlay into memory.
- 60 - *Call Resident System Extension:* special function for loading RSXs only.
- 98 - *Free Blocks:* returns to free space any blocks that have been allocated, but not permanently recorded on disk.
- 99 - *Truncate File:* truncates the specified file to the indicated random record number.
- 100 - *Set Directory Label:* creates or updates the directory label which indicates what extended directory options are active. For example, perform access date and time stamping. MP/M compatible.
- 101 - *Return Directory Label Data:* returns the directory label data byte. MP/M compatible.
- 102 - *Read File Date Stamps and Password Mode:* returns password and time stamp mode for specified file. MP/M compatible.
- 103 - *Write File XFCB:* creates or updates the XFCB for a specified file. MP/M compatible.
- 104 - *Set Date and Time:* sets the internal date and time. MP/M compatible.
- 105 - *Get Date and Time:* returns the internal date and time. MP/M compatible.
- 106 - *Set Default Password:* allows setting of a file password before a file is accessed. MP/M compatible.
- 107 - *Return Serial Number:* returns the 6-byte CP/M Plus serial number.
- 108 - *Get/Set Program Return Code:* allows a program to set a termination code for access by other programs which may follow.
- 109 - *Get/Set Console Mode:* allows setting of control parameters for certain BDOS console functions.
- 110 - *Get/Set Output Delimiter:* allows the string delimiter used in function 9 to be set to another value.
- 111 - *Print Block:* print the block of data pointed to by a CCB on the console.
- 112 - *List Block:* print the block of data pointed to by a CCB on the system list device.
- 152 - *Parse Filename:* parse a filename and prepare a file control block for use.

OF INTEREST

by Michael Wiesenber

Impressions of the West Coast Computer Faire

It seems *de rigueur* for computer columnists to chronicle their impressions of the Computer Faire, so here are mine. As you all know, the West Coast Computer Faire, run by Jim Warren (one of *DDJ*'s first editors), happens each spring at San Francisco's Civic Auditorium and Brooks Hall, with symposia and workshops at the San Franciscan and Holiday Inn hotels. Many call the Faire the most important microcomputer conference of the year.

It was more crowded than last year. Also more hype. The most impressive display was that of **Perfect Software**, obviously designed with great thought by marketing folks. Some computer businesses are just beginning to realize that good products don't necessarily sell themselves; they have to be *sold*. The Perfect folks used the principle well, as they lured you up a carpeted ramp lit on either side by flashing bulbs synchronized to simulate a lighted path travelling into the darkened interior recesses wherein brilliant blue laser blasts pierced clouds of smoke. Displays and booths everywhere else in the Faire were out in the open and jammed up against the wares of other companies; but PS had, probably at considerable expense, bought a large corner nook and turned it into a mysterious subterranean cave. As you stepped off the ramp, your eyes slowly adjusted to the gloom and you found yourself on a railed platform from which two staircases descended into a maze of monitors on pedestals, all displaying Perfect Software products. Giant frameworks of steel girders supported laser-emitting devices that randomly shot blue pencils of light above the heads of the crowd, creating moire patterns in clouds of dry-ice steam. A disembodied, amplified, sepulchral voice, describing the virtues of various Perfect products, floated through and around the din of the crowd.

Elsewhere, **Texas Instruments** put on a robot show. A wheeled contraption carrying a TI 99/4A on a tray, having a TV lens for a face and a monitor mirroring all it saw where its mouth belonged, wandered through the crowd near the TI booth, trading wisecracks with a "real" person dressed up as Charlie Chaplin (and symbolizing,

perhaps, the dominance of the TI machine over IBM?) and carrying on apparently intelligent conversations with bystanders. I am familiar enough with robotics to know that this "robot" must have been controlled at a distance by human beings. I looked around for, but could not find, some seemingly innocent person perpetually draining a coffee cup, but in actuality speaking into a microphone concealed therein.

Both software and hardware were on sale for greatly reduced prices. If you know precisely what you're looking for, computer fairs probably have the best bargains anywhere. But, *caveat emptor*: not all of the exhibitors will be back next year.

The machine that impressed me the most was the Dynalogic **Hyperion**, the truly portable, beautifully designed 16-bit system that I described last month. The version I saw, the Hyperion Plus, costs close to \$5000, but you can get one without quite so many bells and whistles for under \$3400.

The machine that may well start a new trend in quality low-cost computing is the **Humdinger**. This tiny Z80 color computer with CP/M (described in detail below) costs but \$129 yet offers features found only in computers costing literally thousands more.

Ah, yes, then there's **Lisa**. Wonderful machine. Maybe the best user interface for a micro commercially available. The mouse is easy to use, moves quickly anywhere on the screen, and instantaneously displays information any way you want it, without having to touch the keyboard. But \$10,000? If they want to compete in the same ballgame with the PC, Apple will have to price Lisa in the same ballpark.

Through all the chaos glided Jim Warren on roller skates, constantly coordinating his show through a walkie-talkie that rarely left his lips.

In addition to manufacturers with products to display, acquisition editors for major publishers kept an eye out for potential authors of promising material, and software makers were on the lookout for new programs. If you have a book or software to sell, you'll find buyers at the Faire.

On Sunday at 5 p.m., the sated crowds were quickly hustled out into some of the worst rain San Francisco had experienced in years.

I was suffering from sensory over-

load, but glad I had attended. The same thing happens when I spend more than a few hours at a first-rate art museum.

Hard PHD or Toaster for Your System

The **Computer Service Company** offers 16 Mb Winchesters for most systems for \$2595, 8 Mb for \$2195, and double 5Mb removable subsystems with two free cartridges for \$2795. These are variously called **PHD 8x8**, **PHD 4x4**, **PHD 8x8KP** (for KayPro, for example), **PHD 8x8S** (S-100), all of which are 5½-inch drives, and **Toaster** (two 3.9-inch drives). The systems include drive, parallel interface, Z80 adapter (or adapters for virtually any other computer), transportability between computers, power supply, diagnostics, format, sector sparing program, driver, six-month warranty, and (here's the best part) *free* installation by The Computer Service Company, FOB Mountain View, California. While I'm giving them a mention, The Computer Service Company also rents all kinds of computer equipment, from Osbornes at \$5 a day, dot matrix printers at \$2.50, floppy disk drives at \$2.50, hard disks at \$7.50, to monitors at \$1.25 (add about one-third to include service), and they offer phone consultation on all forms of hardware and software maintenance and design for \$35 per hour. **Reader Service No. 101.**

Graphics Like A Word Processor

Graphics Processing System, for 48K Apple II Plus, from **Stoneware**, manipulates and edits images like a word processor. It will also mix and change colors at will, edit or erase a portion of a picture merely by defining its boundaries, zoom or reduce any portion of a picture four or 16 times (with the stored image having a greater resolution than that on screen, reproducible depending on the capabilities of the printer or plotter), rotate images in two dimensions, duplicate images on screen and to and from disk, change proportionality of portions or all of images, overlay in separate colors, and access the 16K RAM card. The system is compatible with graphics tablets,

light pens, and various plotters and graphics printers. \$179. Reader Service No. 103.

A Good Case

Comp Cases by the Computer Case Company make almost any small system portable, inexpensively. Literally a custom built suitcase that exactly fits your IBM PC, Apple, TRS-80, etc., various monitors, printers, and other accessories, the Comp Case is built from mahogany plywood, has padded handles, brass hardware, key locks, vinyl cover, triple-thick, saddle-stitched vinyl at the edges, rubber feet, custom interior foam padding, nylon velcro straps, and interlocking top and base. Once your system is in a Comp Case, you need never remove it, so you can leave cabling in place and easily set up the system. Comp Cases vary in price from less than \$100 for many peripheral or accessory cases, to \$109 for a housing for Apple II with one drive, to \$129 for Apple II with two drives and a monitor or TRS-80 Model III, to \$139 for Apple III with drives and printer. Reader Service No. 105.

A Real Humdinger

The **Humdinger** from Venture Micro is a Z80 color computer with a "real" keyboard, 4K RAM, 8K BASIC in ROM, eight-color video, four-voice sound generator, free game cartridge, RF modulator, and parallel, serial, cassette, cartridge, joystick, expansion, and EPROM interfaces, for \$129. You can add 16K RAM for \$39.95, 64K for \$99, voice synthesizer for \$69.95, disk controller for \$75, 5½-inch drive for \$210, CP/M for \$79, word processor for \$45, Pascal for \$59, an 8088 for \$119 (you'll also need the 8088 BASIC ROM for \$124.95), and an 8087 for \$299, travel case, graphics table, 80-by-24 video, user-defined graphics, real time clock calendar, editor/assembler, various game cartridges and cassettes, extended BASIC, COBOL, Forth, C, Logo, and Pilot. Ten new cartridge and cassette programs per month are planned. Reader Service No. 107.

Dot Matrix Printer with Daisy Wheel Quality

The **Santec S700 Printer** from Western Technology offers letter quality by printing each line four times with minute advances between passes,

at a throughput of 32 to 58 cps. Since it prints 960 dots per inch, you'll need a magnifying glass to distinguish this mode from a daisy wheel output. A correspondence mode makes two passes at each line, with quality better than that of the best dot matrix printers, at a throughput of 65 to 195 cps. And the draft quality mode is as good as the best dot matrix printers. Up to 12 fonts, ranging in size from 7 to 12 points, can be intermingled simultaneously, with no pause in printing. Formatting commands, inserted in the text, are performed by the printer, rather than the computer, with total user control over margins, spacing, tab settings, justification (incremental and proportional), centering, boldface, underlining, and graphics. This remarkable printer costs under \$4000. Spellbinder, the CP/M word processing software from Lexisoft, has a special version configured for the Santec. Reader Service No. 111.

Two APs

VIZ:::APL from EASI APL Systems is virtual-memory APL for Z80 microcomputers, and some 16-bit microcomputers with a Z80 board. This full implementation of APL has an overlaid interpreter and virtual work area limited only by disk space, runs under CP/M, interfaces with high-resolution graphics, uses double-precision, floating-point arithmetic, and has dynamic symbol table allocation. I saw the language demonstrated

on an Osborne I at the West Coast Computer Faire, and was impressed with its fast, direct-mode vector calculations and transformations. No price on this one, but use the Bingo Card for more information. Reader Service No. 115.

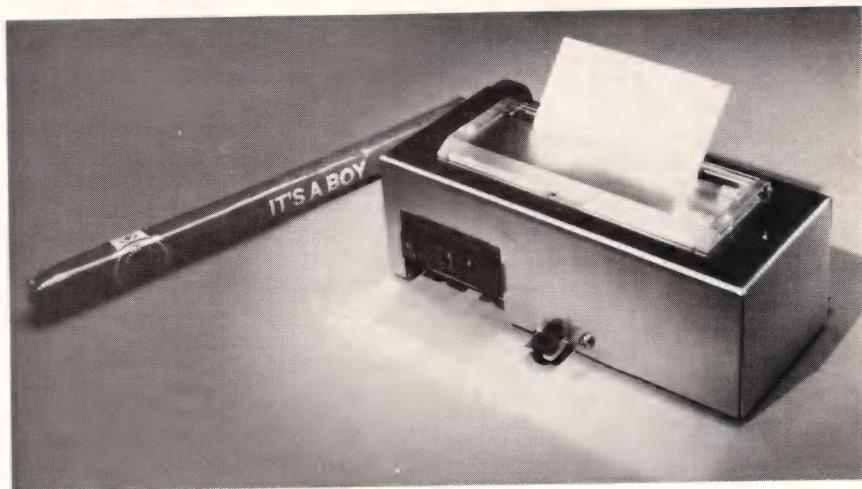
APL.68000 by the Computer Company is a full APL that runs under CP/M-68K, UNIX, and VersaDOS on the Sage Models 2 and 4, Forward Technology's Gateway Work Station microcomputers, the Pixel 100AP, the Corvus Concept, and "soon" on all 68000-based micros. Reader Service No. 117.

1/4

The **Forth-79 Version 2** compiler from MicroMotion for most Z80 CP/Ms 1.4 and 2.whatever, including Apple, comes with screen editor, macroassembler, string processing, three-bit arithmetic, floating point, 200 pages of tutorial and reference documentation, and hi-res for Apple and North Star, and costs from \$99.95 (doesn't anything ever sell for an even \$100?) to \$139.95. Reader Service No. 119.

Wooden Clay?

Perhaps one of the better pieces of inexpensive software for the IBM PC seen at the West Coast Computer Faire was **Cosmic Nightmare** from Wood & Clay Hi-Tech Gameware. "Earth explodes," they say (I saw it



Hot Little Printer

The **EUY-3T** thermal printer from Panasonic is about the size of a good 5-cent cigar ("What this country needs is a good . . ." inexpensive printer), 4.69 by 1.79 by 2.64 inches. With dot-addressable graphics, 40 characters per

line, battery power, bi-directional printing at 1.2 lines per second, and a weight of 14 ounces, the printer will cost under \$100 in OEM quantities. Reader Service No. 109.

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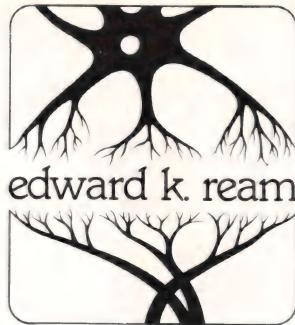
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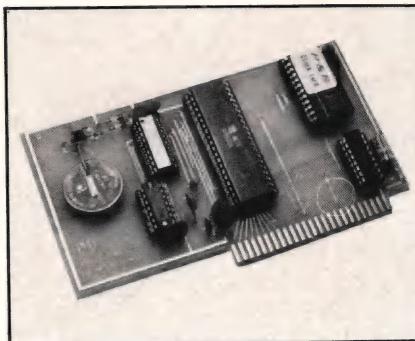
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happen — wonderful graphics), "and you're the only one left! All the phantoms of the universe are released, and you have to fight enemies so real you won't believe it's a dream." The disk costs \$32.50. If you want real arcade action on your PC, you'll want to order joystick controllers at \$29.95 each from W&C. Other games available include **Falklands Fury**, with "all the action of real life warfare" (whoopie!, what fun!) and **Jungle Madness**, in which you "play Tarzan, swing from vines, and fight off savage pygmies," also \$32.50 each. (California, add 6.5% sales tax.) Reader Service No. 121.

The Sorcerer Lives!

I often think my computer system is unusual and incompatible with anyone else's. When I say I have a Sorcerer, most people say, "A what?" So I'm always pleased to find someone trying to keep this wonderful Z80 machine alive. In this case, it's **ISIS** (the International Sorcerer Information Service), a "not-for-profit" monthly newsletter to give Sorcerer owners a means of exchanging information. Membership is \$15 in Canadian funds in Canada, and

US dollars elsewhere. Contact **ISIS**, c/o Maurice Dow, 84 Camberley Cres., Brampton, Ontario, Canada L6V 3L4; or use the reader service card. Reader Service No. 123.



Clock Your Apple

dat.a.clock, for Apple II, II Plus, and IIE, from **P & B Research Consultants** keeps time in date, month, and year, with a two- to three-year battery, has an externally accessible EPROM, and costs \$55 in kit, or \$85 assembled (plus \$2 p&h). Reader Service No. 113.

Commodore Camaraderie

A VIC-20 users group is being formed by the **New York Amateur Computer Club**. Although the UG will meet in New York City, NYACC is soliciting members throughout the country to join "on a correspondence basis." Both types of VIC-20 users are sought, computer novices and the knowledgeable who bought the machine "just for the fun of it. What we would like to do is put these two types together and get some synergism going." If enough interest is generated, NYACC will plan to expand to other Commodore machines, like the 64 and the Pet. Reader Service No. 125.

Make a Beeline for the C Line

The **C Line**, a free public access electronic bulletin board for users of UNIX and C, has close to two megabytes of public domain C software just itching to be downloaded onto the computers of those with any standard terminal or computer with modem who dial (201) 625-1797, 8 pm to 9 am weekdays (Eastern time) and 24 hours weekends. The C Line, say sponsors In-

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BX=0000  BP=0000  DS=1984
CX=0000  SI=0000  ES=1985
DX=0000  DI=0000  CS=2001
          IP=0002

PL ZR NC NV UP NA PE EI
2001:0002  9C      PUSHF   BP
2001:0003  55      PUSH    SI
2001:0004  66      PUSH    ES
2001:0005  06      PUSHF   BP,SP
2001:0006  BBEC    MOV     BP,SP
2001:0008  B3E048  24      SUB    SP,4BH
2001:0009  B95EG9  34      MOV    F4H[BP],BX
2001:000E  B95EF4  34      MOV    F4H[BP],DX
2001:0011  B0761E  LEA    SI,1EH[BP]
2001:0014  F3A4    REPZ   MOVSB
2001:0016  241C    AND    AL,00011100B
2001:0018  45      DB     69
                      TYPE YOUR COMMENT!
                      TAG A LINE
                      ;SET A BREAKPOINT
                      .CHANGE RADIX!
                      :FORCE "DB" OPCODE
MEMORY DUMP
ENTER DUMP ADDRESS > 304-0056  Absolute Address=03C66  Segment:Offset=03C4:0056
03C4:0050  41 43 43 49 49 20 03 55-60 50 4F 62 54 20 32 20  ASCII SUPPORT 2
03C4:0060  20 2D 2D 20 43 BF 64 65-53 60 69 74 68 20 38 36  -- CodeSmith-86
03C4:0070  20 4D 41 4B 45 53 20 44-45 42 55 47 49 4E 47  MAKES DEBUGGING
03C4:0080  20 41 20 42 4C 41 53 54-21 20 20 20 20 20 20 20  A BLAST!
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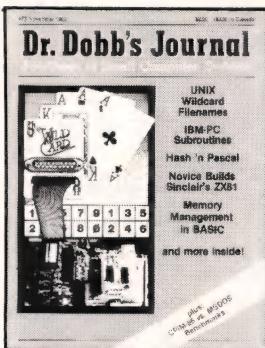
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Clinic

(Continued from page 12)

our CP/M 2 system had. So it was a disappointment to find that an assembly that ran in 25 seconds under CP/M 2 consumed 23 seconds under CP/M 3. A ten percent improvement didn't seem like much of a return on our investment in RAM cards. We set out to find out what the CP/M 3 BDOS was doing with all those buffers.

Inter-Bank Peeping

We wrote an experimental tool called SHOWBCB. It finds and dumps the two chains of the BCBs to the console. This is not easy, because the Disk Parameter Header, the chain anchors, and all the BCBs are in bank zero, while the program runs in bank one. It is made possible by the XMOVE and MOVE BIOS functions. MOVE is normally an intra-bank block copy function. If XMOVE is called first to inform MOVE of the source and target bank numbers, the next call on MOVE will transfer data from a source address in one bank to a target address in another. With them, our program could get copies of the control blocks into bank one so it could display them.

One problem slowed us down for a few hours. The program was written to play by the rules of CP/M 3, making its

BIOS calls by way of BDOS function 50. It turns out, however, that the BDOS uses MOVE (and XMOVE?) in the course of executing function 50. So by the time we reached the BIOS for the MOVE function, the BDOS had already been there and thus had used up the parameters we had given to XMOVE. What we meant for an inter-bank move was thus magically transformed into an intra-bank move. We reverted to calling MOVE and XMOVE directly. This is possible provided that the BIOS routines and the calling program's stack are all in non-banked storage.

The Directory BCB Chain

Examine Figure 1 (page 91). It shows the BCB chain immediately after a cold start. The only disk I/O that has been done to this point is the load of CCP.COM and its load of SHOWBCB.COM. The lengthy display of the data BCBs has been trimmed to save space.

The first byte of a BCB is the number of the drive for which it holds a sector, and FFh indicates an unused buffer. Only one BCB is active in each chain. In the directory chain you can see that four BCBs have been used, but three of them have since been discarded. Old BCBs for

track 2 sectors 1, 2, and 4 can be seen. Presumably sector 3 was read as well, but its BCB doesn't show.

Track 2 sector 4 was read again, and its BCB is still active. This BCB probably represents the I/O done to open SHOWBCB.COM. Thanks to its directory hashing table, the BDOS didn't have to scan the directory for SHOWBCB; it was able to read the one sector that contained its entry. However, it did have to read that sector because the residual BCB for the same sector had been discarded.

This seems reasonable on reflection. It's only by reading a directory sector and testing its contents against the hash table that the BDOS can detect a change of disks. If it didn't make that test, it would be as liable to trash a directory as MSDOS is. Extra directory I/O is a reasonable price to pay to avoid that danger to data integrity, so the fact that the BDOS seems to toss away its active directory BCBs shouldn't disturb us too much.

The Data BCB Chain

Now look at the chain of data BCBs. Two have been used, but only one remains active. The discarded one probably represents the last sector of CCP.COM; track 4 sector 6 is about the right location for it

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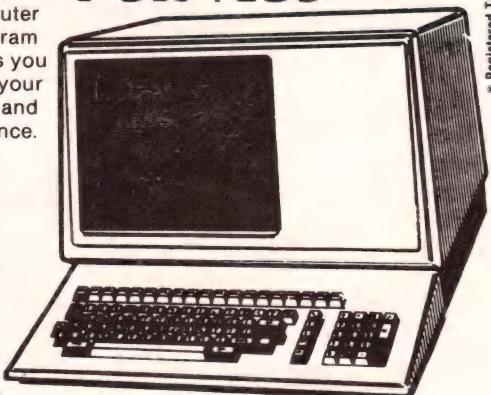
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on this disk. Of course, CCP.COM occupies 3.5 one-kilobyte sectors. Why does only one BCB appear? Probably because the BIOS's cold-start code uses a multi-record read to load the file. When the BDOS knows it will be transferring eight or more 128-byte units from adjacent disk locations to adjacent storage locations, it probably skips allocating a deblocking buffer and reads the sector directly into storage. The last sector of the file is not all used, so a BCB was allocated to hold it while the last few records were pulled out of it. The one active BCB probably represents the only sector of SHOWBCB.COM.

Examine the addresses in the "bcb" and "link" columns; you can see how the BDOS's LRU algorithm works. BEC3 is the last BCB assembled in the BIOS. When the system is loaded, it is at the end of the chain. Whenever the BDOS needs a BCB, it removes the last one from the end of the chain and inserts it at the head of the chain. In Figure 1, you can see that the BCB at BEC3 was moved from tail to head, and the same was done to the BCB that originally preceded it, BEB4. The original chain head, BAA9, has aged two positions. We can tell how many BCBs the BDOS has used by counting the BCBs that precede BAA9. This remains true only for 71 uses, when the chain wraps.

BCB Use for Input

Our next experiment was to run an assembly that did input but no output ("rmac showbcb \$1brzszpz"). The assembler had to read a total of 29 sectors: ten sectors of SHOWBCB.ASM (twice each), and nine sectors in three library files. Figure 2 (page 91) shows the data BCBs afterward. The only one still active, BE4B, represents the load of SHOWBCB.COM. The two oldest, BEB4 and BEC3, are left over from Figure 1. The six in between are the total result of loading RMAC, reading the source file twice, and reading three libraries. The BCB at BEA5 probably represents the last sector of RMAC (it, like CCP.COM earlier, would have been loaded with a multi-record read). That leaves five BCBs to account for all 29 sectors of data.

Two things stand out in Figure 2. First, the BDOS does not use a new BCB for every new sector of data it reads. If it did, Figure 2 would be 24 BCBs longer than it is. Perhaps the BDOS assigns only one BCB to each open file (three libraries plus the source file twice equals five). Perhaps it reuses a BCB whenever its current sector is completely used up and the next sector is for the next adjacent record of the file. The second scheme would produce the same numbers in this case of all-sequential I/O, but would allow for the accumulation of more BCBs to a direct-access file.

Either way, the result is that for sequential input, the BDOS effectively

assigns a single BCB to each open file. Sequential data does not accumulate in the BCB chain. When a file is used twice in succession (as is the source file in an assembly), it will be read twice from disk. The only effect of the BCB chain is to eliminate the second read of the *last* sector. Now we can see why an assembly

runs at essentially the same speed in CP/M 3 and CP/M 2.

The second thing that stands out in Figure 2 is that what little data was accumulated has since been discarded. The data residual from RMAC's execution was tossed out sometime between the end of RMAC and the start of SHOWBCB. The

culprit had to be the CCP — it was the only program to run in that interval. We ran CCP.COM under SID to see what it would do.

What it did was issue BDOS request 98, Free Blocks. This BDOS function is supposed to release any disk blocks that were allocated to files that were never closed. It recovers disk space that might otherwise remain inaccessible until the disk was logged in again (possibly a long time in CP/M 3, since disks are only logged in when control-C is pressed). Exactly that problem occurs under MSDOS when the IBM Pascal compiler aborts, but under MSDOS you have to run CHKDSK to recover the space.

BDOS function 98 has a laudable goal, but it seems to have an unfortunate side effect. It not only cleans up the allocation vector, it also puts FFh into every active BCB! We proved that by killing the call on function 98 in CCP.COM (it's at location 458h) and re-running the experiments. With the modified CCP, the BCB chain after the assembly had eight active entries instead of eight dead ones and one live. However, this had little effect on performance, since the active entries represented only the last sectors of their respective files.

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```
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BA7C FF 000008 00 08 0002 0004 4400 00 BA8B
BA8B FF 000000 00 00 0002 0001 4800 00 BA9A
BA9A FF 000018 00 07 0002 0002 4C00 00 BA31 *
BA31 FF 000000 00 00 0000 0000 3000 00 BA40
BA40 FF 000000 00 00 0000 0000 3400 00 BA4F
BA4F FF 000000 00 00 0000 0000 3800 00 BA5E
BA5E FF 000000 00 00 0000 0000 3C00 00 0000 #
```

Data BCB chain...

```
bcb drive record wflg "00" track sector buffad bank link *

BEB4 00 000BF0 00 04 0031 0003 7800 03 BEC3
BEC3 FF 0000B8 00 00 0004 0006 7C00 03 BAA9 *
BAA9 FF 000000 00 00 0000 0000 5000 00 BAB8
BAB8 FF 000000 00 00 0000 0000 5400
BAC7 FF 000000 00 00 0000 0000
BAD6 FF 000000 00 00 0000 0000 03 BE69
BAE5 FF 000000 00 00 0000 0000 6400 03 BE78
BAE4 FF 000000 00 00 0000 0000 6800 03 BE87
BAE5 FF 000000 00 00 0000 0000 6C00 03 BE96
BEA5 FF 000000 00 00 0000 0000 7000 03 BEA5
BEA5 FF 000000 00 00 0000 0000 7400 03 0000 #
```

Figure 1.

Data BCB chain...

```
bcb drive record wflg "00" track sector buffad bank link *

BE4B 00 000BF0 00 04 0031 0003 5C00 03 BE69 *
BE69 FF 000C68 00 01 0033 0008 6400 03 BE5A *
BE5A FF 000C60 00 07 0033 0005 6000 03 BE78 *
BE78 FF 000D08 00 04 0036 0004 6800 03 BE87
BE87 FF 000CE0 00 05 0035 0005 6C00 03 BE96
BE96 FF 000D30 00 03 0036 0003 7000 03 BEA5
BEA5 FF 0006E8 00 01 001D 0008 7400 03 BEB4
BEB4 FF 000BF0 00 04 0031 0003 7800 03 BEC3
BEC3 FF 0000B8 00 00 0004 0006 7C00 03 BAA9 *
BAA9 FF 000000 00 00 0000 0000 5000 00 BAB8
BAB8 FF 000000 00 00 0000 0000 5400
BAC7 FF 000000 00 00 0000 0000
BAD6 FF 000000 00 00 0000 0000 03 BE69
BAE5 FF 000000 00 00 0000 0000
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Figure 2.

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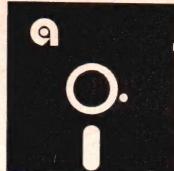
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BCB Use for Output

We checked BCB use following an assembly that produced PRN, REL, and SYM files. We expected to see BCBs for at least the last sector of each output file. We did not. We don't know what space the BDOS is using to block the physical sectors of output files, but it isn't space taken from the BCB chain.

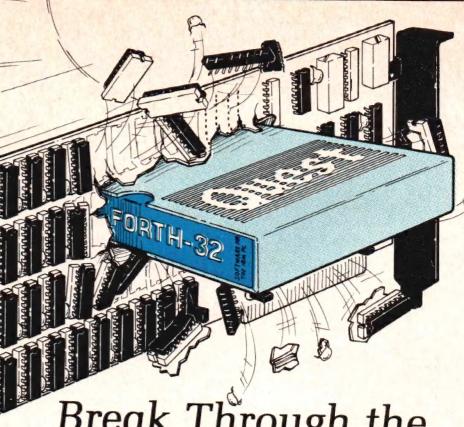
To make sure that we weren't seeing the result of some clever use of multi-record writes in RMAC, we ran a test using the Magic Wand PRINT program with disk output. This program has abysmal disk I/O logic; it alternates reading and writing of 128-byte units. Under CP/M 2, with a BIOS that had only a single sector buffer, PRINT caused a seek, read, seek, read, write sequence for every 128 bytes of throughput. Under our 2.2 BIOS with separate read and write sector buffers, it ran better. In fact, it ran better than under CP/M 3, where PRINT takes about 10% longer than under our improved 2.2 BIOS! And its output didn't leave any evidence in the BCB chain.

Here again, it seems that the CP/M 3 BDOS is throwing away an opportunity to speed up processing. All output goes straight to disk; if it then becomes input, it has to be read back again. The file that one program writes, another program is going to read. The editor's output is input

to RMAC; RMAC's REL file is input to LINK; and its PRN file is input to TYPE or PIP. It's all very well to speed up direct access, but we should keep in mind that (1) the majority of CP/M commands read files sequentially, and (2) commands are used in sequence, with the output of one feeding the input of the next. That situation is exactly right for the LRU algorithm, but the BDOS isn't capitalizing on it.

Well, almost exactly right. If the BDOS buffered all the sectors it read, and also buffered all the sectors it wrote, some problems would arise. If an output file was larger than the total buffer pool, its last few sectors would displace its first few. The next command's input of the first few sectors of the file would kick out the next few, and so on. A ripple would run down the BCB chain, causing each saved sector to be discarded just a few sectors before it was needed as input.

But the BDOS does not buffer all the sectors it reads. If it kept the present logic for sequential reading but buffered all output sectors, then the ripple would never develop. One BCB would be used to read the leading sectors that had been displaced by later output. Eventually the input requests would work around to the sectors that had not been displaced. From there to the end of the file, the second command would operate at RAM speeds.



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Summary

A sophisticated algorithm for sector buffering under CP/M would make special provision for COM files, encouraging the retention of commands in storage. It would probably use separate chains of BCBs for input and output, with some kind of heuristic to shuffle buffers from one chain to the other on the fly. In fact, CP/M 3 has enough resources to make it quite interesting as a case study in performance optimization. It could be the grist for a Ph.D. thesis in Comp. Sci., in fact.

But the existing algorithm is not sophisticated and, while it may be effective for direct access, it is definitely not optimal for the kind of sequential access that is the bread and butter of any CP/M system. Until it is improved (CP/M 3.2?), we recommend that you not spend a lot of money on RAM cards when moving to CP/M Plus. One 48Kb system bank should provide as many sector buffers as the BDOS can use effectively.

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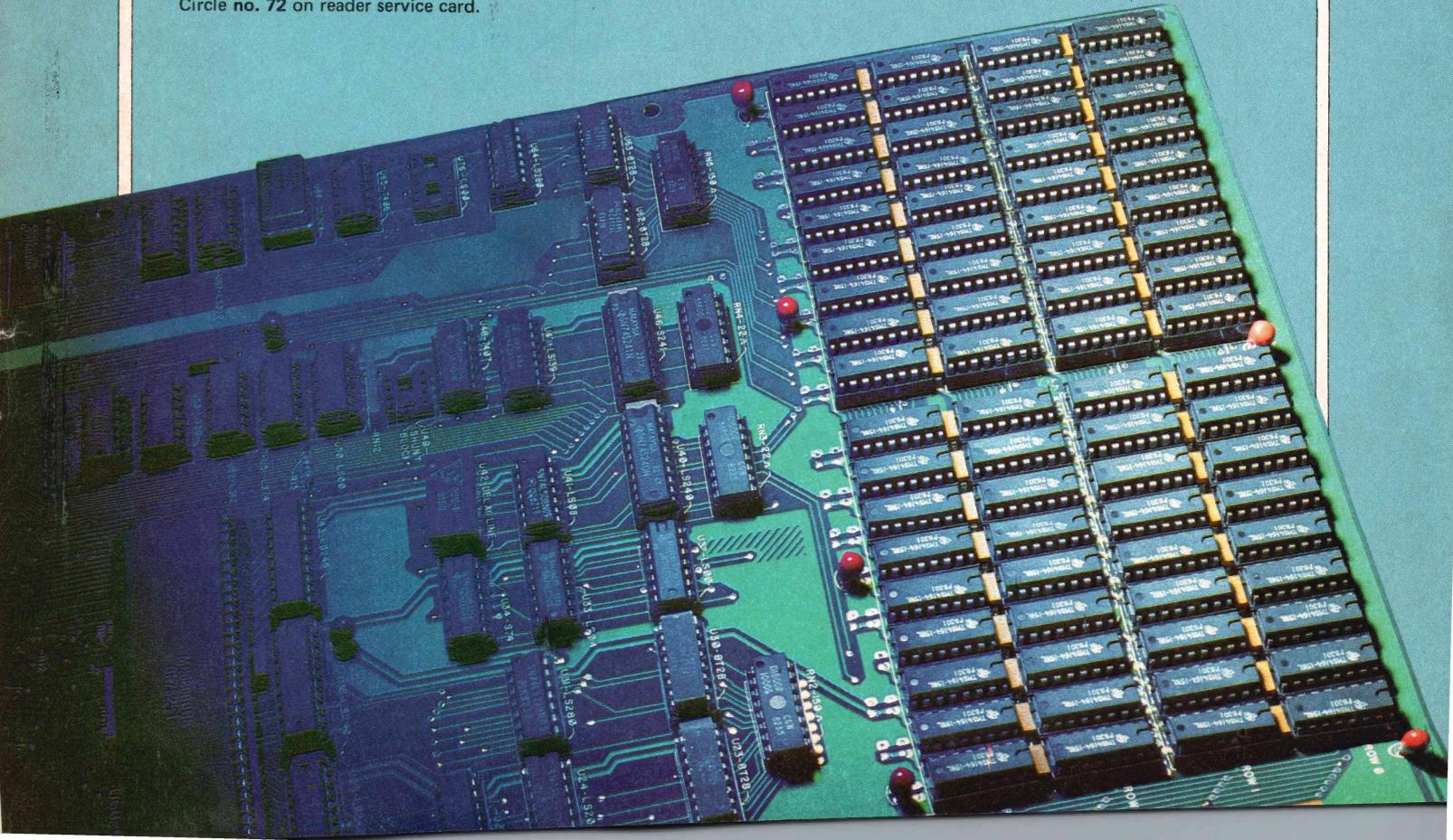
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